ZWICK'S ISLAND LANDFILL

ENVIRONMENTAL INVESTIGATIONS

FINAL REPORT

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ZWICK'S ISLAND LANDFILL
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1.0 INTRODUCTION

1.1 BACKGROUND

In the 1980's the Ministry of the Environment (MOE) initiated a program to investigate and monitor all active and closed landfills in the Province. This program was divided into four phases:

Phase I:	the creation and continual updating and verification of an inventory listing all active and closed waste disposal sites in the Province;
Phase II:	preliminary file and field investigations to classify and establish a priority for further investigations;
Phase III:	investigating and monitoring to assess site hydrogeology as well as surface and ground water contamination potential at selected sites; and
Phase IV:	investigations of remedial options at sites identified during Phase III.

Zwick's Island, located at the south end of the City of Belleville on the Bay of Quinte, is the location of a closed landfill site which has been selected as a Phase III site. The landfill site was operational in the 1950's and 60's and received mainly municipal wastes. Based on interviews with former landfill staff, it is believed that some commercial and industrial wastes, including liquid wastes, were also landfilled. A dyking system was used to construct the landfill with dykes built out into the bay and refuse deposited behind the dykes. The landfill has been closed since 1971.

Upon closure the landfill was covered and converted to parkland which is owned and managed by the City of Belleville. A portion of the property, in the north east corner, is owned by the Ramada Inn, which operates a Ramada Inn hotel on the property. The general physical features of Zwick's Island are shown on Figure 1.

1.2 OBJECTIVES

The Zwick's Island landfill represents a potential source of contaminant loading to the Bay of Quinte. The Bay of Quinte has been identified as an area within the Great Lakes which has relatively poor water quality. To understand and ameliorate contaminant loading to the bay where possible identifying contaminant sources and their rate of loading is necessary. In order to assess the potential impacts to the Bay associated with the Zwick's Island landfill the MOE retained Gartner Lee Limited (GLL) to undertake a Phase III environmental investigation of Zwick's Island. Although, a detailed review of remedial options (e.g., a Phase IV Study) was outside the scope of this work, remedial options were addressed on a conceptual scale in this study.

The six primary objectives for the study were:

1. to assess any existing or potential future landfill leachate impacts on ground water;

2. to determine any existing or potential future landfill leachate impacts on surface waters;

3. to determine any existing or potential future landfill gas impacts;

4. to determine the contaminant loading pathways and calculate approximate loads to the Bay of Quinte;

5. to identify any impacts to the environment or potential risks to human health; and,

6. to recommend remedial options, where needed.

2.0 APPROACH

A site specific study program was developed to meet the study objectives listed in Section 1.2. This program included a desk top inventory of existing information,

conversations and correspondence with municipal employees and regional and local MOE staff, a subsurface soils drilling program, a ground water monitoring program, a surface water monitoring program, and a landfill gas monitoring program. The work carried out under each of these parts of the work program is outlined in Sections 2.1 through 2.5.

2.1 DESK TOP INVENTORY

A series of air photos from 1953 to 1987 were used to identify the extent and process of filling over the period the landfill was operational. Historical water quality data for the Bay of Quinte and the Moira River provided by the MOE were reviewed. Recent study results on the Bay of Quinte were provided by the Bay of Quinte Remedial Action Plan. Geological and hydrogeological information was provided by the Ministry of Transportation through their work on the construction of Highway 62 on Zwick's Island. All of the background data reviewed was used in the design and interpretation of the drilling and monitoring programs.

2.2 SITE VISIT

A site visit was conducted on April 2, 1990 in order to relate the data collected during the desk top study to actual field conditions, and to collect additional data on the physical setting of the site. In addition to meeting with the MOE, GLL staff also met with a Municipal employee who worked at the landfill in the 1960's. This meeting provided first-hand information with respect to the nature of the refuse and the filling locations. The information obtained through the site visit assisted GLL in finalizing the drilling program as well as providing input to the health and safety protocols which would be followed during the course of field work.

During the site visit surface water drainage and pathways were observed and noted. Conductivity measurements of surface water were taken at several locations around the site along with observations of iron staining and vegetation loss in roadside and drainage ditches in the northeast corner of the Island. Observations were also made as to the occurrence of ground settlement, locations of exposed refuse, and evidence of leachate seeps.

During the course of the field visit, GLL staff visited the City of Belleville Town Offices and obtained historical maps of Zwick's Island. This information assisted in establishing the original shoreline of the island and the landfilling locations.

2.3 SUBSURFACE INVESTIGATIONS

As noted in Section 1.2, the first objective of the study was the assessment of existing or potential future landfill leachate impacts on ground water. In addition to the preliminary studies described in Sections 2.1 and 2.2, subsurface field investigations were carried out to provide data for this assessment.

The subsurface investigations consisted of the following tasks:

- drilling of boreholes and collection of soil samples in order to identify the nature and extent of native soils, landfilled wastes, and cover soils;

- installation of ground water monitors in each borehole and measurement of ground water levels in each monitor in order to identify ground water flow directions and gradients;

- carrying out of slug tests in selected monitors to provide an indication of the hydraulic conductivities of off–site soils and refuse;

- recovery of ground water samples from each monitor for laboratory chemical analysis; and,

- excavation of test pits in selected areas to determine if wastes were present in several areas of the original Zwick's Island.

A total of nine boreholes were drilled during the period from April 5 to April 10, 1990, using a truck–mounted soil drilling rig. Borehole locations are shown in Figure 2. Stratigraphic logs for each of the boreholes and a summary of ground water monitor construction details are presented in Appendix B. Test pits were excavated using a rubber–tired backhoe on August 29, 1990, at the locations shown in Figure 2.

The ground water sampling program was designed to provide data as to ground water quality within the landfill area, and also to facilitate assessment of the relationship between ground and surface water systems. Thus, ground water and surface water samples were collected

concurrently. Monitoring events were scheduled for May and August 1990 to represent wet and dry weather respectively. However, due to an error in the request for laboratory analyses, some of the May samples had to be recollected in June and as such ground and surface water samples were taken on May 3, June 8 and August 29, 1990. Water levels were measured in each monitor prior to recovery of ground water samples.

A blind duplicate sample from BH2 was labelled as BH10 and submitted to the laboratory for each monitoring event. This provided quality control of the analytical results.

Ground water samples were analyzed for the following parameters:

General Chemistry

* pH
* Alkalinity
* Conductivity
* Hardness
BOD (5 day)
* Total Dissolved Solids (TDS)
Suspended Solids

Metals

Aluminium	Sodium
Boron	Nickel
Barium	Phosphorus
Beryllium	Lead
Calcium	Silver
Cadmium	Strontium
Cobalt	Thallium
Chromium	Titanium
Copper	Vanadium
Iron	Zinc
Potassium	Zirconium
Magnesium	Manganese
Molybdenum	

Anions

Fluoride	Bromide
Phosphate	Nitrite
Sulphate	Nitrate
Chloride	

Nutrients

* Ammonia
TKN
Total Phosphorus

Organics

* Dissolved Organic Carbon (DOC)
* Organo Chlorine Pesticides / PCB's Scan
** Volatile Organic Scan
Phenols

* not analyzed in May samples
** not analyzed in June samples

The results of the water level monitoring are presented on Table C-1 in Appendix C. The results of the ground water chemistry analyses are compiled in Appendix D.

Proper health and safety precautions were observed during the field work due to the use of heavy machinery during the drilling and test pitting work, and due to potential for exposure of the field crew to landfilled wastes of unknown nature. A detailed discussion of all field methodologies, the health and safety procedures observed, and quality assurance / quality control measures carried out is presented in Appendix A.

2.4 SURFACE WATER MONITORING PROGRAM

The second study objective as outlined in Section 1.2 was to determine the impacts that the landfilled wastes and resultant leachate has on surface water quality. It was recognized that this objective was one of the most important study objectives. The desired approach was to design and implement a monitoring program that would facilitate assessment of the relationship between surface water pathways and the primary off-site receptor, the Bay of Quinte. As discussed in Section 2.3, to achieve this goal the surface water program was closely integrated with the ground water program so that the inter-relationship between the ground and surface water systems could be established.

Surface water sampling events coincided with ground water sampling events. Surface water samples were collected on May 3, June 8, and August 29, 1990. Dates of monitoring events are plotted on Figure 3 with precipitation measured in Belleville from April to September. This figure demonstrates that both the May and June samples were taken under relatively wet weather conditions, and that the August samples were taken during dry weather conditions.

Surface water monitoring locations were established through information obtained from the desk top inventory and the site visit. Nine surface water stations were initially established as shown in Figure 2. Five stations (SW1-5) were located on the property within the only flowing on-site surface water course, an intermittent drainage ditch located near the Ramada Inn which discharges to the Bay of Quinte. The remaining four stations (SW6-9) were located near shore in the Bay of Quinte. Stations SW6, SW7, and SW8 were located immediately downgradient of several ground water monitors in order to assess changes in the water chemistry from the refuse through the peripheral berm and into the bay.

A quality control station, SW10, represented a blind duplicate of SW4 and was collected for quality control purposes at the time of each monitoring event.

Through the surface water monitoring in May and June, areas of direct and potential surface water impacts were identified. In order to quantify these impacts on water quality in the Bay of Quinte seven additional stations (SW11-17) were monitored in August 1990. The locations of these stations are shown on Figure 2.

Stations SW11, SW12, and SW13 were used to establish background water quality within the Bay of Quinte and the Moira River. Stations SW14, SW15, and SW16 were taken at the sediment–water interface and corresponded with the locations of stations SW6, SW7, and SW8, respectively. These sediment–water interface samples were used to determine whether ground water discharge to the Bay of Quinte through the subsurface could be detected. Station SW17 was added to assess any localized impacts and potential health risks to users of the beach located on the south side of the island immediately west of Hwy 62.

Water samples were submitted to Barringer Laboratories for analysis. Surface water samples were analyzed for all of the same parameters chosen for analysis of the ground water.

The following field measurements were taken at each surface water station:

- Flow (where applicable)
- Temperature (water)
- Conductivity
- pH
- Dissolved Oxygen

A discussion of the methodology followed during the course of the surface water field work is presented in Appendix A.

2.5 LANDFILL GAS INVESTIGATIONS

The third main objective of the study was to determine any existing or potential future landfill gas impacts. Of main interest was the presence or absence of combustible gas in locations where the accumulation to explosive levels could potentially occur. Of secondary interest was the potential for the landfilled wastes to be acting as a source of volatile gases. Data for these assessments was recovered by the following methods:

- hand–augering of shallow boreholes and measurement for combustible gases in the vicinity of the Ramada Inn and other on–site buildings; and,

- measurement for the presence of volatile vapours in soil samples recovered during the borehole drilling program.

A total of nine hand–augered shallow boreholes were advanced on May 3, 1990 in the locations shown on Figure 2. The shallow boreholes were monitored using a combustible gas meter. The meter provides a direct indication of the explosivity of the gas in relation to the lower explosive limit of methane. The combustible gas monitoring data is compiled in Appendix C.

Each soil sample recovered during the borehole drilling program was monitored with a photo–ionizing volatile vapour detector. This instrument provides a relative indication of the presence or absence of volatile vapours. These monitoring data are compiled on the borehole logs presented in Appendix B.

3.0 PHYSICAL SETTING

3.1 GEOGRAPHIC SETTING

The Zwick's Island Landfill is located in the southern portion of the City of Belleville, on Lots 2 and 3 of Concession 1 of Hastings County. The site is situated on the north shore of the Bay of Quinte, and covers an area of approximately 14 hectares.

Zwick's Island is bounded on the north by Highway 2, and on the west, south, and east by the Bay of Quinte. The mouth of the Moira River is situated at the north–east corner of the island. Hwy 62 extends southward from Hwy 2 and bisects Zwick's Island. The general site area is shown on Figure 1.

3.2 SITE HISTORY AND PRESENT USE

The landfill site was operated from the early 1950's until its closure in 1971. During its operating life both municipal and industrial wastes were received at the site. It was reported by the former landfill staff interviewed during the initial site visit that landfilling was conducted primarily by dumping wastes behind earthen dykes built out into the bay. The dykes were constructed from random earth fill and construction rubble. The landfilling occurred both eastward and northward from the original Zwick's Island, which comprises the south–west portion of the present Zwick's Island. The approximate pre–landfill extent of

Zwick's Island as well as the interpreted areal extent of the landfilled wastes are shown on Figure 1.

Following completion of landfilling activities, the site was closed and a park established. Site closure consisted of placement of a soil cover over the wastes and planting of sod and trees. Numerous small structures such as a band shell and concession stand have been built on the site following the landfill closure. The only large structure that has been constructed on the landfilled wastes is the Ramada Inn, located at the northeast corner of the park. This structure is built on piles founded on bedrock, and incorporates an open parking area at ground level beneath the hotel structure.

The park is intended for daytime use, and has such features as tennis courts and open playing fields. A public swimming area exists along the southwestern shore. A recreational marina exists in the north–east corner of the site at the mouth of the Moira River.

3.3 SITE HYDROLOGY

The hydrology of Zwick's Island is characterized by road side ditches which have intermittent flow in response to runoff events and local seepage zones. There are no surface water courses which drain into the site, and all surface water contributions to the site are in the form of precipitation. During runoff events surface water accumulates in low lying areas and infiltrates into the ground water system and/or discharges to the Bay of Quinte through drainage ditches. The largest of these ditches is located immediately west and south of the Ramada Inn. The main drainage ditches are shown on Figure 2.

3.4 SUBSURFACE CONDITIONS

The surficial geology in the vicinity of the site can be generally characterized by a veneer of glacial drift composed primarily of sands and gravels, underlain by limestone of the Trenton–Black River Formation. The landfilling activities, as well as earlier construction works such as the original Hwy 14 causeway, have resulted in the deposition of waste materials over native soils, as well as the surficial reworking of the native sands and gravels.

The drilling carried out as part of this study was aimed primarily at determining the subsurface conditions within the landfill area. Borehole logs detailing the subsurface

conditions encountered are presented in Appendix C. Borehole locations are shown on Figure 2. A north–south oriented cross–section through Zwick's Island is presented in Figure 4.

The stratigraphy underlying the landfilled area generally consists of the following strata, from surface downwards:

- brown to grey silty clay fill;
- landfill refuse contained in a matrix of silt or clay; and,
- brown to grey fine to coarse sand, containing gravel.

The surficial fill can be characterized as a non–homogeneous silt or clay fill containing a varying sand and gravel content. This material can be described as stiff to hard, with standard penetration test values ('N' values) ranging approximately from 15 to 50. Rootlets were typically encountered within the upper metre of this stratum. In one location, BH 7, a zone of pink–coloured silty clay was encountered between 0.5 m and 0.9 metres below surface. The reason for this colouration was not readily identifiable. No chemical analysis was performed on these samples as it was beyond the scope of this study. The fill unit comprises the final cover for the majority of the landfilled wastes, and was observed to vary in thickness from 0.5 to 2.1 metres. In numerous areas of the park greater thickness of fill soils were placed over the landfilled refuse to create the presently existing landscaping.

In two locations (BH's 1 and 3) boreholes were advanced through the earth berm which extends around the perimeter of the landfilled wastes. The berm material was similar in all aspects to the cover material encountered over the wastes in other areas. The berm was observed to vary in thickness from 2.7 to 3.1 metres, and in both cases was underlain by a sand unit. It was not possible to determine if this sand was part of the fill soils placed during berm construction, or part of the sand unit encountered in numerous boreholes advanced through the wastes.

The landfilled refuse was observed to consist of wastes such as brick, glass, rubber, timber, cloth, paper, plastic, and wire. Identifiable fragments of waste were typically contained in a brown to black soil–like or fibrous matrix. The refuse was typically soft, with 'N' values ranging from 2 to 5. The landfilled refuse was observed to vary in thickness from approximately 1.0 to 3.8 metres.

The stratum underlying the refuse consists primarily of grey to brown fine to coarse sand, with varying gravel content. The sand varied from very loose to very dense, with 'N' values ranging from 6 to over 50. In borehole 7 a stratum of clayey silt was found underlying the refuse.

In numerous boreholes drilling was terminated due to auger refusal on an assumed bedrock surface. This surface was encountered at depths varying from 4.1 to 4.8 metres below ground.

Excavation spoil from the test pits excavated on the original Zwick's Island consisted of sands and gravels, as well as some clay and silt fills. The sands and gravels are believed to be indicative of the native soils on the island.

4.0 LANDFILL GAS

4.1 POTENTIAL FOR LANDFILL GAS

Landfill gas is produced by the decomposition of organic materials, such as those routinely found in municipal landfill waste. Landfill gas consists of primarily methane (generally 40 to 70% by volume), carbon dioxide (generally 30 to 60% by volume), as well as hydrogen sulphide and water vapour. Landfill gas typically also contains minor quantities of volatile organic compounds such as benzene, toluene, and other solvents, as well as organic acids and esters, and organo sulphur compounds. The production of landfill gas can continue for decades following the landfilling of the waste, but generally decreases with time.

Landfill gas moves within the unsaturated zone by either advection or diffusion mechanisms, and movement is influenced by a number of factors such as the gas permeability of the wastes and cover soils. The water table is generally a barrier to the movement of landfill gas, although certain constituents of the gas such as carbon dioxide and certain solvent compounds may dissolve in ground water and thus migrate with ground water flow.

Under certain circumstances the presence of landfill gas presents a health and safety hazard, since the gas can be explosive, corrosive, and possibly toxic. The major risk typically associated with landfill gas is methane accumulation in enclosed spaces at concentrations ranging from approximately 5 to 15% by volume in air. Within this range, the methane–air mixture can explode given a source of ignition and a supply of oxygen. The venting of landfill gas through cover soils to the atmosphere is generally not considered to be a significant hazard due to its immediate dilution with ambient air.

Potential concern exists at the Zwick's Island Landfill site due to the presence of several structures built over the wastes which could possibly cause the accumulation of landfill gas. These include the Ramada Inn, as well as the several park structures noted on Figure 1.

4.2 OCCURRENCE OF LANDFILL GAS

The results of the combustible gas monitoring carried out in shallow hand–augered boreholes at various locations over the landfilled wastes are presented in Table C–2 in Appendix C. The gas monitoring locations are shown in Figure 2. It may be seen from the results that the highest reading observed was 6% of the lower explosive limit of methane, indicating that no significant concentrations of landfill gas were detected at any of the locations monitored.

The soil samples recovered during the borehole drilling were monitored for the presence of volatile vapours. The results of this monitoring are reported on the borehole logs presented in Appendix B. The monitoring was carried out using a "Micro TIP" photo–ionizing volatile vapour detector. The units reported are relative, and can be interpreted very approximately as a scale of parts per million. The instrument is not selective in detecting any specific compounds, but rather detects the relative ionizability of the constituents of the air being sampled. The results indicate that no significant concentrations of volatile vapours were being produced from the soil samples. All "Micro–TIP" readings recorded during the field

work were less than 10 units, which are generally indicative of insignificant concentrations of volatile vapours.

5.0 GROUND WATER AND LEACHATE

5.1 PHYSICAL HYDROGEOLOGY

As discussed in Section 2.3, the first objective for this study was the assessment of the impact of the landfilled wastes on ground water. The starting point for this assessment was to develop an understanding of the physical hydrogeological conditions which exist at the site. Because of the site's close proximity to the Bay of Quinte, the connection which was perceived to exist between site ground water and surface waters in the bay, as well as the shallow depth at which bedrock exists beneath the site, it was believed that the shallowest ground water flow system was of most significance to this study. For this reason, deeper flow systems that may exist in the bedrock were not investigated.

Water levels in the Bay of Quinte were typically measured concurrently with ground water levels. However, during the June and August monitoring events inaccessibility to staff gauges precluded recovery of Bay of Quinte water levels. To compensate for this, lake levels for June and August were calculated from data obtained from the U.S. Army Corps of Engineers. To check the accuracy of the data, calculated levels were compared to the measurements which could be obtained from Zwick's Island in April and May, 1990. The calculated levels were found to be within 0.1 m of the measured values for these times. It was thus reasoned that the calculated levels for June and August would be within this level of accuracy. Based on this correlation, water levels in the Bay increased from 74.9 mASL in April to 75.0 mASL in May, then decreased to 74.6 mASL in August.

The shallow ground water table surface within Zwick's Island was found to occur between 0.5 to 2.0 metres below ground surface in May, 1990, and between 1 to 2 metres below ground in August. The water table surface is generally flat, with the highest water table surface elevation consistently measured at BH 8. Over the majority of the area of the island, the ground water table surface was found to exist approximately 0.1 metres above the water level

in the Bay of Quinte in May, and approximately 0.2 metres above the bay water level in August. The orientation of the ground water table surface as interpreted from water level measurements taken May 3 and August 29, 1990 are presented in Figures 5 and 6, respectively.

Ground water flow within the shallow flow system occurs in a radial pattern outward into the Bay of Quinte. Ground water flow thus generally occurs from the island to the bay in westward, southward, and eastward directions. Based on the water level measurements, horizontal gradients to the Bay generally increased from a range of 0.003 to 0.010 in May, to a range of 0.007 to 0.012 in August.

Based on the topography of Zwick's Island and the surrounding area, it is believed that the primary source of ground water recharge for the shallow flow system is precipitation. Because of the relatively small difference between ground water levels within the island and those in the Bay of Quinte, it is possible that the Bay of Quinte water level could change sufficiently (e.g., as a result of seasonal fluctuations and storm activity) so that temporarily flow occurred from the Bay into the ground water system of Zwick's Island.

It may be seen from the borehole logs that the earth berms which physically contain the wastes are relatively non–uniform. As well, a sand unit was identified beneath the berms and the wastes in most boreholes. For these reasons, it is believed that a significant pathway exists for horizontal flow out of the wastes into the Bay of Quinte. During periods when flow may have occurred inward from the Bay of Quinte to the ground water system within Zwick's Island, flushing of the near shore part of the wastes with bay water could have occurred.

Slug tests were performed on monitors installed in BH's 1, 5, 6, and 7. The slug test results are presented in Appendix C.

The monitor in BH 1 was screened across both the clay / silt berm material and the sand, thus the hydraulic conductivity values produced by the slug testing (1 to 5.5 x 10^{-5} m/s) are believed to be somewhat smaller than would be expected for the sand unit alone, and considerably larger than would be expected for the clay / silt berm material alone.

The monitors in BH's 5, 6, and 7 were screened primarily through refuse and fill soils. The range of hydraulic conductivities produced by slug tests from these monitors varied from 1.3×10^{-4} m/s to 1.2×10^{-6} m/s.

Based on water level data, the overall flux of ground water to the Bay of Quinte from areas where waste exists on Zwick's Island was estimated to vary from approximately 31,000 L/d in May to approximately 39,000 L/d in August. These fluxes are based on averages of calculated fluxes in the vicinity of BH's 1, 3, and 8. These approximations were made using Darcy's law ($Q = KiA$) and the following assumptions:

- k, the hydraulic conductivity of the perimeter berms, was chosen as 1×10^{-5} m/s (i.e., the approximate k of the sand unit).

- i, the hydraulic gradient which exists across the berms, was chosen to vary from 0.003 to 0.010 in May to 0.007 to 0.012 in August.

- A, the cross sectional area through which flux occurs, was chosen to vary from 5400 m^2 in May (based on a saturated window height of 3.4 m and a shoreline length of 1600 m) to 4800 m^2 in August (based on a saturated window height of 3.0 m and a shoreline length of 1600 m).

(Note: the shoreline length of 1600 m is only that length of shoreline where wastes are present in the immediate proximity of the shore. The total shoreline length of the island is approximately 2300 m, which includes the shoreline of the original Zwick's Island)

To put the magnitude of this ground water flow in perspective, the mean annual discharge of the Moira River when converted to a daily flow is approximately 2.6×10^9 L/d (Environment Canada, 1987). Thus the ground water discharge from the portion of Zwick's Island where wastes are present represents less than 0.002% of the mean discharge of the Moira River.

5.2 GROUND WATER QUALITY

A total of three sets of ground water samples were collected from each monitor in May, June, and August, respectively. Originally it was intended to collect only two sets of samples, corresponding to dry and wet weather periods. An extra set of samples was collected in June since several desired parameters were accidentally excluded from laboratory analysis in the May sampling.

Analyses were performed for all of the parameters as requested by the MOE for this study. A listing of these parameters is presented in Section 2.3. Results of the analyses for each of the three sets of samples are presented in Appendix D.

Ground Water Quality Parameters of Interest

All of the analytical parameters were assessed in the review of the data. However, this discussion is limited to several key parameters which were found to be typical landfill leachate indicators for this site. Some of the indicators were also chosen because they are significant in the assessment of surface water quality and therefore needed to assess any link between surface water impacts and ground water quality. These indicator parameters are conductivity, dissolved organic carbon, phenols, chloride, iron, and ammonia.

Ground Water Quality Criteria

Where relevant, concentrations were compared to values specified in the Ontario Drinking Water Objectives (ODWO), a criteria by which ground water quality is typically evaluated. It should be noted that in this case the ODWO are of limited value since ground water from within the landfill would not be considered as a source of potable water. Ground water quality was not evaluated according to the MOE's Reasonable Use Policy, since all ground water from the site flows into the Bay of Quinte and becomes surface water.

General Trends

Concentrations of most parameters included in the analytical programme are significantly less than would be expected for ground water recovered from within typical landfilled wastes. Many of the parameters, including some of the analyses for major ions such as chloride, fluoride, as well as metals such as lead and zinc are within the limits specified for drinking water in the Ontario Drinking Water Objectives.

The generally low values are believed to be the result of the method used to place the wastes (e.g., dumping into standing water behind the earth berms), as well as flushing over the years via the significant hydrogeological connection which exists between the wastes and the Bay of Quinte.

It may be seen from a review of the data that concentrations of most parameters decrease from the interior of the Zwick's Island outward towards the Bay of Quinte. Concentrations of various parameters measured during the dry weather sampling in August from boreholes and surface water stations recovered progressively closer to the Bay are plotted in Figures 7.1 to 7.7. It is believed that this trend can be attributed to the increased degree of dilution that ground water undergoes along flow paths from the interior of the island towards the bay.

It was seen that concentrations of many parameters were generally higher in the dry weather samples collected in August than the wet weather samples collected in May and June. This is attributed to the smaller quantity of recharge and to less dilution of ground water with infiltration.

<u>Conductivity</u>

Ground water conductivities varied from a low of 798 µS/cm observed in BH 1 during the June sampling event, to an overall high of 2890 measured in BH 4 during the August sampling event. The values plotted in Figure 7.1 show that values decrease as potential for ground water dilution with bay water increases.

It is seen that values are generally larger during the August sampling event when ground water levels were lower than during the May or June events.

<u>Chloride Concentrations</u>

Chloride concentrations were observed to vary from an overall low of 14 mg/L in BH 2 during the June sampling event, to an overall high of 503 mg/L in BH 6 during the August sampling event. Viewed from the perspective that the maximum chloride value exceeded the ODWO limit for chloride by only approximately two times, the concentrations observed are small for ground water in contact with landfilled wastes.

As with conductivity, chloride values were generally seen to be highest during the August sampling event when ground water levels were low, as well as being higher in monitors located in the island interior. The relationship of concentration as a function of increased dilution potential is seen in Figure 7.2.

Iron Concentrations

Iron concentrations varied from a low of 9.5 mg/L observed in BH 3 during the May sampling event to a high of 47.6 mg/L observed in BH 5 during the June sampling event.

No specific trend in iron values between the wet and dry weather samplings could be discerned. As with most other parameters, concentrations decreased as distance of the sampled monitor to the Bay of Quinte decreased as shown in Figure 7.3.

Phenol Concentrations

Phenol concentrations were observed to vary from less than the detection limit of 0.0005 mg/L measured in several monitors during the May and June sampling events, to a high of 0.0195 mg/L in BH 4 also during the June sampling event.

The high value of 0.0195 exceeds the ODWO for phenol of 0.002 by approximately 10 times. Viewed from the perspective that the ground water at this monitor is in contact with landfilled wastes, this value is considered to be low.

The relationship of phenol concentration as a function of increased dilution potential is seen in Figure 7.4.

Ammonia Concentrations

Ammonia concentrations (as N) varied from an overall low of 3.8 mg/L in BH7 in June, to an overall high of 93 mg/L in BH 4 measured in June. These concentrations translate into unionized ammonia concentrations of 0.02 mg/L to 0.55 mg/L respectively, when pH and water temperature are accounted for.

As with many of the other parameters discussed, ammonia concentrations were found to decrease with decreasing distance of the sampling location to the bay. This trend is shown in Figure 7.5.

DOC and TKN

As with other parameters, both DOC and TKN values were seen to decrease with decreasing distance to the Bay of Quinte. These trends are depicted in Figures 7.6 and 7.7.

DOC concentrations ranged from a low of 7.4 mg/L measured in BH 7 in June, to a high of 52.0 mg/L measured in BH 4 in August. DOC analyses were not performed on samples recovered in May. TKN values varied from a low of 4.8 mg/L observed in BH 7 in June, to a high of 112 mg/L observed in BH 4 in August.

Volatile Organic and Organochlorine Pesticides

No significant concentrations of volatile organics were detected during the course of the sampling and analyses. The maximum concentration of any of the EPA Method 624 volatiles detected was 54 µg/L of M + P xylene detected in BH 5 during the May sampling event. The volatiles that were detected (such as benzene, toluene, and trichloroethane) are believed to be typical of volatiles in landfill leachates. Volatiles were not observed to be more prevalent in any one sampling location.

No significant concentrations of organochlorine pesticides were detected in any of the ground water samples. The largest concentration of any of the parameters from the pesticide analyses was 0.029 µg/L Aldrin detected in BH 8 during the June sampling event. Concentrations slightly above the minimum detection limits for these analyses (typically 0.001 to 0.002 µg/L) of a range of organochlorine pesticides were found in most samples, with no significant concentrations observed in any single sampling location.

6.0 SURFACE WATER

Surface water samples were collected coincidentally with the ground water samples in May, June, and August. As with the ground water sampling, it was originally intended that only two sets of surface water samples be collected corresponding to wet and dry periods. An extra set of samples was collected in June since several desired parameters were not analyzed for in the May sampling.

Analyses were performed for all of the parameters as requested by the MOE for this study. A listing of these parameters is presented in Section 2.3. Results of the analyses for each set of surface water samples are presented in Appendix E.

6.1 SURFACE WATER QUALITY PARAMETERS OF INTEREST

In assessing potential impacts to surface water quality from Zwick's Island it was imperative to establish the relationship between ground water quality and surface water quality. Since the ground water is essentially leachate it was important to assess surface water in terms of leachate chemistry characteristics.

As with the analysis of the ground water data, while all analytical results were reviewed, several parameters were selected for discussion based on their importance as overall indicators of surface water quality. The parameters that were chosen for discussion of ground water quality were also chosen as indicators of surface water quality, since these parameters are good indicators for landfill impacts on surface water. These selected water quality parameter were; Conductivity, Chloride, Iron, Ammonia, Phenols and Dissolved Organic Carbon (DOC).

Conductivity serves as a good control parameter and is an excellent indicator of general water quality changes (MOE, 1989). High conductivity measurements relative to background in surface water is usually indicative of a source pollutant.

Chloride was chosen for detailed examination in surface water since it is an important leachate indicator and because a direct hydraulic connection exists between the ground and surface water systems, as discussed in section 5.1.

Of the various metals found in landfill leachate iron is generally found in the highest concentrations. Iron is important with respect to surface water. When iron hydroxides form they can cause low pH values which are toxic to aquatic life (MOE 1989). As well, iron precipitation on fish gills and the exoskeleton of aquatic invertebrates is hazardous to these organisms.

Ammonia, which is highly soluble in water, is associated with landfill leachate since it results from the decomposition of organic matter. Generally, in surface water, ammonia concentrations are evaluated as unionized ammonia, since this form is toxic to fish and aquatic life at low concentrations. Unionized ammonia can be calculated knowing total ammonia concentration and the pH and temperature of the ambient water.

Phenols have many sources such as decaying vegetation, industrial wastes, municipal sewage, and pesticides, and are relatively mobile in water. Since both municipal and industrial wastes are believed to have been landfilled at Zwick's Island phenols may be associated with leachate. Phenols are toxic at low concentrations and taint fish flesh at very low concentrations (1 µg/L) (MOE 1984).

Dissolved Organic Carbon (DOC) is composed of humic substances and partly degraded plant and animal material (MOE 1989). It is associated with landfill leachate as it is a result of the decomposition of organic matter. DOC concentrations in landfill leachate can range from 200 to 30,000 mg/L (Freeze and Cherry, 1979). Discharge of high DOC concentrations can deplete dissolved oxygen concentrations which affects fish and aquatic life.

6.2 WATER QUALITY CRITERIA

All of the surface water quality data was evaluated in terms of the relevant objectives, guidelines, and criteria governing surface water quality in Ontario.

In Ontario, surface water is evaluated in terms of the Provincial Water Quality Objectives (PWQO) which were established by the MOE (1984). These objectives were established for the protection of fish and aquatic life, and are generally the most stringent of any provincial objectives for water. However the list of water quality parameters for which the PWQO provides objectives is limited. Of the leachate indicator variables discussed in this study only

iron and unionized ammonia have PWQO's. To supplement the PWQO's for variables relevant to leachate contamination the Canadian Water Quality Guidelines for the protection of fish and aquatic life (Environment Canada 1987) were used as well as Environment Canada's guidelines on expected normal ranges for various parameters in uncontaminated waters. Surface water quality results for selected locations and parameters are compared to various guidelines in Table 1. The complete set of surface water quality results are provided in Appendix E.

6.3 SURFACE WATER QUALITY

The main factors which influence the quality of surface water adjacent to Zwick's Island are the quality and quantity of ground water discharging into the Bay of Quinte, background water quality in the Bay and the Bay's dilution capacity.

Ground water discharges to the Bay of Quinte through the peripheral berm of the landfill and via the drainage ditch in the north east corner of the site adjacent to the Ramada Inn.

As discussed previously in Sections 5.1 and 5.2, the ground water quality and discharge rate is significantly influenced by ground water levels. Results of the wet and dry weather monitoring events suggest that surface water quality in the unnamed ditch is influenced by the changes in ground water quality, and that surface water concentrations are a function of background concentrations, ground water discharge, and the dilution capacity of the receiver.

Temporal Distribution

Concentrations of various parameters in surface water of the unnamed ditch were observed to vary from wet to dry weather monitoring as ground water quality changed.

In the spring when ground water levels are higher, concentrations of various parameters in leachate are relatively small while in the summer when ground water levels are lower leachate becomes more concentrated. The surface water receiver, the Bay of Quinte, provides great dilution capacity. The dilution capacity of the Bay is a function of lake levels which fluctuate throughout the year. The concentrations in surface water of numerous parameters were higher in the summer than the spring at the Bay of Quinte stations (SW6, SW7, SW8, SW9). The higher concentrations in the summer may be a function of changes in

dilution capacity from spring to summer. Table 1 shows the results of the surface water monitoring events for a selected group of water quality variables.

Higher ground water levels in the spring result in seepage areas in the drainage ditch immediately to the west of the Ramada Inn in the vicinity of SW1 and SW3. While the leachate concentrations are generally smaller in the spring there is little to no dilution provided for the ground water discharge in the ditch until it reaches SW4, located in the small channel leading to the Bay of Quinte. Figures 8.1 to 8.6 demonstrate the high concentrations for selected parameters found in the ditch in the spring and the dilution as it is discharged eastward towards the Bay of Quinte. In the summer, the lower ground water levels result in minimal, direct ground water seepage into the ditch, and as such lower concentrations are observed at SW4.

Spatial Distribution

In a comparison of the water quality of monitoring stations located within the Bay of Quinte, SW9 had the poorest water quality. This is likely a result of its close proximity to refuse and the limited circulation and dilution capacity of the Bay in the area in which it is located. Of the on-site monitoring stations (SW1-5), SW1 and SW3 typically showed the highest concentrations.

The water quality of the samples collected at SW1 and SW3 is indicative of the concentrations observed in the leachate. Peak iron concentrations of 15.9 mg/L and 17.6 mg/L were found at SW1 and SW3, respectively. These concentrations represent iron levels about two orders of magnitude greater than the PWQO for iron of 0.3 mg/L. Conductivity and Chloride concentrations were also high compared to the values observed in the Bay of Quinte at SW6. Table 1 shows the results of a selected group of water quality parameters for each monitoring station and event, and highlights those results which exceed objectives or normal ranges.

Generally few of the results of analyses were found to exceed the limits listed in the PWQO's, with the exception of pH which was found on occasion to be above 8.5, the upper limit.

The TKN and Phosphorus concentrations were found to be relatively large both in all on–site ditches monitored and in the Bay. The higher concentrations of TKN in the Bay are believed to be in part a result of high background concentrations. However it should be noted that the landfill represents a source of nutrient loading to the Bay of Quinte.

Of the Organochlorine and volatile compounds analyzed for, only Heptachlor was found in the Bay of Quinte, at a concentration of 0.002 µg/L at SW9 on August 31, 1990 which exceeded the PWQO of 0.001 µg/L. However, at SW11 in the Moira River both Heptachlor and Aldrin were found at 0.004 µg/L and 0.003 µg/L, respectively. Both of these concentrations were above the PWQO of 0.001 µg/L.

Comparison of Surface Water Bottom and Surface Samples

During the August sampling event, three surface water locations off the shore of Zwick's Island were sampled at the sediment–water interface and at the surface of the water column (stations SW6 and 14, SW7 and 15 and SW8 and 16). The objective of sampling at two locations within the water column at a given location was to determine if there was any difference between surface water quality and water quality at the sediment / water interface where leachate seepage zones were believed to be located.

Figures 9.1 to 9.6 present a graphic representation for selected parameters of the August data from the surface and bottom samples. Generally there was little difference between the bottom and surface samples. DOC, Conductivity and Chloride showed surface and bottom concentrations approximately equal to each other. However, iron concentration were noticeably higher in bottom samples. This is likely a result of iron deposition through sedimentation processes and its release to surface water as a result of microbial activity and redox potential at the sediment water interface. Ammonia concentrations were observed to be slightly higher in the surface samples while TKN generally slightly higher in the bottom samples. The lower ammonia concentrations observed in the bottom samples could be a result of bacterial nitrification (Wetzel, 1983).

The Bay of Quinte provides extensive dilution capacity and therefore interpreting the concentrations observed in the Bay is extremely difficult. Given the general proximity of these stations to the wastes at Zwick's Island, it is likely that the slightly higher

concentrations are a result of leachate discharge. A more extensive data base than a single monitoring event could yield more statistically viable results.

Comparison of Surface Water Quality to Background Values

In August, a background surface water station (SW13) was established to compare the water quality adjacent to the landfill to that out in the Bay. A second background station (SW11) was established at the mouth of the Moira River to compare surface water quality to that of the Moira River. As with the surface / bottom samples discussed above, the results are limited to a single monitoring event.

Concentrations of the majority of the analytical parameters detected at SW13 were generally in the same range as at stations adjacent to the landfill. No obvious trend in the spatial distribution of the water quality amongst all of the August Bay of Quinte samples could be discerned. Analytical results for the sample collected in the Moira River (SW11) also showed no apparent differences to other Bay of Quinte samples with the exception of chlorides.

When compared to the chloride concentrations in the Bay of Quinte (SW5, 8, 10, 12, 17) the concentration of chloride in the Moria River (SW11) was lower. The mean chloride concentration in the Bay in August was 12.65 mg/L with a standard deviation of 0.35. The concentration in the Moria River was 10.1 mg/L which is lower than the Bay by more than 7 standard deviations, which suggests a relatively significant difference. However, the Moira River concentration is based on a single sample and thus not representative of fluctuations that may occur on the river.

This higher concentration in the Bay may be a result of chloride inputs from the landfill and other discharges to the Bay, however, more data would be required to quantify this difference and better define a chloride source.

7.0 IMPACTS

One of the overall goals for this study was to identify both the environmental and potential human health effects that are being posed by the presence of landfilled wastes on Zwick's Island. The data that has been generated during the course of the project work has led to an understanding of the physical nature of Zwick's Island and its surface and ground water systems, as well as the chemistry of these surface and ground waters. The logical next step from the acquisition of this data is to identify the receptors which may be affected by contaminants originating from the wastes, and the pathways by which contaminants may move from the wastes to these receptors.

The receptors which could be affected and the pathways by which contaminants may move from the landfilled wastes are discussed in Section 7.1. A preliminary interpretation of the relative importance of these pathway / receptor combinations is also presented in Section 7.1. Those pathways determined to be most significant to the natural environment or to human health are discussed in greater detail in Sections 7.2 and 7.3, respectively.

7.1 IDENTIFICATION OF RECEPTORS, CONTAMINANT PATHWAYS AND CONTAMINANT LOADINGS

7.1.1 Receptors

The Bay of Quinte is the component of the natural environment which is most directly affected by the wastes at Zwick's Island. As discussed in Section 7.1.2, the majority of pathways by which contaminants may move from the wastes lead directly to the Bay. Although numerous other receptors would subsequently be affected by contaminant loading to the Bay of Quinte (e.g., members of the food chain relying on the Bay of Quinte as a food source), identification of these was beyond the scope of the present study. The significance of the pathways leading to the natural environment is discussed in Section 7.2.

Humans (e.g., Zwick's Island park users) represent the most significant receptor which could potentially be affected by the wastes at Zwick's Island. The pathways by which humans may be exposed to contaminants from this source are discussed in Section 7.1.2. The significance of these pathways for human receptors will be discussed in Section 7.3.

7.1.2 Pathways

Ground Water Flow Through Perimeter Berms to Bay of Quinte

The movement of ground water from within the landfilled wastes through the subsurfa the Bay of Quinte constitutes the most significant pathway for contaminants to enter the natural environment. As discussed in Section 5.1, it is believed that ground water from within the wastes may move relatively freely to the Bay of Quinte via the sand unit prese beneath much of the perimeter berms. As well, the non–homogeneous nature of the ber soils is believed to present little hydraulic resistance to the movement of ground water to Bay of Quinte.

This pathway can potentially be of significance to humans, since swimming areas exist immediately off the Zwick's Island shore.

Loadings for chloride, iron, phenol, and ammonia have been estimated from three locatio at the west, south, and east areas of Zwick's Island at BH's 8, 4, and 2, respectively and are presented in Table 2. Loading at each of these areas was estimated by multiplying the parameter concentration by the ground water flux from the island to the Bay at that point. Loadings were estimated for both a wet period (e.g., May of June), as well as a dry period (e.g., August) at each location. In addition to loadings at discrete points, loadings from the entire island for May and August for given parameters were estimated. For these estimatio the concentrations of a given parameter at each of three discrete points were averaged then multiplied by the total ground water flux from that portion of the island where wastes exist.

Total calculated chloride loadings from Zwick's Island varied from 4.6 Kg/d in May to 6.7 Kg/d in August. Total iron loadings varied from 1.3 Kg/d in May to 1.0 Kg/d in August. Total phenol and ammonia loadings from the island were relatively constant for the periods studies, at approximately 0.0004 Kg/d and 1.8 Kg/d, respectively. In interpreting the loading estimates compiled on Table 2, it is important to realize that the estimates are based on assumed values and averages, and as such should be treated as approximate.

It may be seen from the loading estimates that the loading did not change significantly from the wet to dry periods studied.

The significance of the magnitude of the loadings will be seen if the values can be compared to loadings of other contaminant sources to the Bay of Quinte (e.g., industries along the Belleville waterfront, the sewage treatment plant, etc.). While the comparison of loading values estimated for Zwick's Island with other sources was beyond the scope of this study, the significance of contaminant loadings to the natural environment via this pathway will be discussed further in Section 7.2.

Ground Water Flow into Surface Drainage Ditches

Ground water seepage into existing surface drainage ditches and subsequent drainage of the ditch water into the Bay of Quinte results in a significant contaminant flux to the natural environment.

This pathway likely provides a smaller contaminant flux to the Bay than the direct movement of ground water through the subsurface into the Bay since some dilution with surface runoff in the ditch occurs. Due to the low flow rates measured in the drainage ditch adjacent to the Ramada Inn, it was not possible to estimate the contaminant loading via this pathway with any degree of certainty.

This pathway is potentially of significance to human receptors since humans (e.g., park or hotel users) may come into direct contact with contaminated water present in the drainage ditches. Further discussion of the significance of this pathway on human receptors is presented in Section 7.3.

Landfill Gas Migration Through Cover Soils to Atmosphere

Landfill gas originating from the refuse may move through the cover soils and vent to the atmosphere. The shallow water table present at the Island limits the downward movement of gas, resulting in gas moving only laterally or upwards. The presence of any enclosed structure over the wastes may allow the gas to collect and increase in concentration.

The gas monitoring carried out during the course of this study was intended to allow a gross assessment of any health and safety risk to the field crew, and to provide an indication of the concentrations of combustible gas that may have accumulated in existing structures. It was

beyond the scope of the study to determine any long term emissions or their effects on the public at large.

Given the scarcity of enclosed structures, the naturally vented design of the hotel, and the very low to non detectable levels of combustible gas in the buildings and shallow hand–augered boreholes, this pathway is not considered as significant for existing site conditions, and will not be considered in greater detail.

Contact of Overland Surface Water Flow with Exposed Refuse

It was observed during the initial site visit that in various places along roadside ditches to the north of the Ramada Inn exposed refuse was visible. Potential exists for overland surface water flow to come into contact with these wastes and mobilize contaminants into the surface water or ground water flow systems.

Though perceived in this case as minor, the presence of exposed wastes poses a concern to human health due to the possibility of direct physical contact with wastes. This pathway will be addressed further in Section 7.3.

7.2 ASSESSMENT OF IMPACTS ON THE NATURAL ENVIRONMENT

As discussed in Section 7.1.2 the flux of contaminants via ground water and from surface drainage represent the major pathways by which the Bay of Quinte is affected by Zwick's Island. These major pathways as well as other minor ones are graphically portrayed in Figure 10.

The assessment of the impact of Zwick's Island on the Bay of Quinte is a complex task with many variables. For the purposes of this study, this assessment has been made in a qualitative manner, based on the following:

- comparison of water quality in the Bay measured during this study with historical data;

- evaluation of the effect that the landfill's physical setting has on its potential to release contaminants to the Bay; and

- evaluation of the location of Zwick's Island with respect to other potential contaminant sources to the Bay of Quinte.

Historical water quality data as provided by the MOE from September 1980 suggests that local impacts to water quality associated with Zwick's Island have reduced over time. In comparing the water quality data from 1980 to the 1990 data collected, it was seen that concentrations were slightly higher in 1980 at near shore stations within the Bay of Quinte. It is noted that little information as to the sampling methods etc. of the 1980 data is known.

The occurrence of this trend is supported by certain aspects of the physical setting of Zwick's Island. First, the ground water system at Zwick's Island is such that there is a continuous hydraulic flux between the Bay and the landfilled wastes resulting in a flushing of the wastes. Leachate concentration thus becomes diluted over time. Secondly, since it is believed that wastes were placed directly into standing water, a significant degree of dilution occurred at the time of landfilling. Thus it is probable that the largest loadings to the Bay of Quinte have already occurred and that loadings will continue to decrease over time. Although outside the scope of this study, a logical next step is to compare the estimated loadings with those of other sources.

While it is recognized that the Bay of Quinte has provided dilution for leachate discharge, it has also served as a sink for contaminants since the time that the wastes were placed and will continue to do so in the future. It is important to recognize that the Zwick's Island Landfill has no attenuation zone which can buffer leachate impacts and thus contaminants migrating with surface or ground water travel a relatively short pathway to the receptor. Comparison of water quality to only PWQOs is an incomplete analysis since PWQOs do not address contaminant loadings over a given period of time. As well, it must be taken into account that the Bay of Quinte has been identified by the International Joint Commission (IJC) as an "area of concern" due to a number of contaminant sources including waste disposal sites, the Belleville sewage treatment plant, and industries located in Belleville. It is reasonable to assume that background water quality within the Bay of Quinte is relatively poor and thus may not provide a significant comparison.

Although not detected in this study, the site does however provide a persistent load of low concentration leachate to the Bay, and therefore some contaminants are entering the Bay of Quinte from Zwick's Island. Thus, given the limited database, localized areas and/or seasonal periods of measurable effects on water quality may occur in the Bay immediately adjacent to the site.

The significance of this loading can only be quantified through comparison with other contaminant sources to the Bay of Quinte. It is believed that this comparison must be performed prior to prioritizing any remedial actions required for the Bay of Quinte.

7.3 HUMAN HEALTH IMPACTS

Presence of Leachate in Drainage Ditches

As discussed in Section 7.1.2, the most significant human health risk posed by the landfilled wastes is the direct seepage of leachate into surface drainage courses which are easily accessible to park users. Although a quantitative human health risk analysis was outside the scope of this study, it is believed that the presence of often undiluted landfill leachate in a park setting should be considered as unacceptable, and thus warrants a high priority for remediation.

Bay of Quinte Water Quality

The effect of the relatively poor water quality in the Bay is a complex issue. In terms of the water quality variables evaluated through the 1990 investigation the water quality of the Bay does not consistently exceed PWQOs. Where PWQOs were exceeded, they were also generally exceeded in offshore sampling locations that would be indicative of background concentrations.

Given the scope of the present study, no comment can be made regarding the impact on human health of Bay of Quinte water quality.

Exposed Refuse

The impacts associated with exposed refuse are not perceived to be large, since the extent of the exposed refuse is limited to small, isolated areas primarily in drainage ditches.

8.0 REMEDIAL MEASURES

Following identification of the impacts originating from the landfilled wastes on various receptors, it is possible to identify several remedial measures to mitigate these impacts. Section 8.1 presents a brief discussion of some measures identified to mitigate direct impacts on human health. Section 8.2 discusses measures identified to mitigate effects on the natural environment.

8.1 REMEDIAL MEASURES TO MITIGATE IMPACT ON HUMAN HEALTH

As identified in Section 7.3, the most significant human health hazard is the presence of relatively concentrated leachate in the open drainage ditch adjacent to the Ramada Inn. The immediate goal of any remedial work to prevent impacts on human health should thus be the prevention of human physical contact with the water in this ditch. Two viable alternatives would be the erection of a security fence around the ditch, or reconstruction of the ditch so that all drainage is conveyed to the Bay of Quinte via the subsurface.

8.1.1 Fencing of Drainage Ditch

Fencing erected along the length of the ditch would serve as a barrier to park user contact with the water present in the ditch. For example, 1.8 m high chain link fencing could be erected along both sides of the 200 m portion of ditch where standing water persists for a cost of $20,000 to $30,000. The fencing considered in this scenario would extend along both sides of the ditch immediately west of the Ramada Inn, and the channel discharging to the Bay immediately south of the Ramada Inn.

Given the considerably greater cost of reconstructing the ditch to convey water via subsurface pathways, this represents a simple and relatively inexpensive option. The main drawback to this option is that the fencing would be immediately adjacent to the Ramada Inn, and could be considered as having a visually negative impact. Also, leachate staining in the ditch would still be visually evident.

8.1.2 Reconstruction of Drainage Ditch to Convey Drainage via Subsurface Pathways

The open drainage ditch could be possibly reconstructed such that seepage is conveyed to the Bay of Quinte via a subsurface perforated pipe surrounded by granular backfill. The subdrain

alignment would be covered over with fill soils and sodded. The ground surface along the alignment could be graded so that a shallow swale existed to direct overland surface water flow directly to the Bay. Drainage from roadside ditches in this area could possibly be routed into the subdrain.

This option provides more benefit than only erecting a fence around the existing ditch, since there would be no negative visual impacts from a fence or from the ditch itself. Viability of this option would depend upon suitability of the existing soils to support a pipe, the existence of adequate grades to allow the pipe to operate hydraulically, as well as the invert elevations of roadside ditches in this area. Providing that a subdrain could be constructed in this location by conventional means, the cost of this reconstruction for the same 200 m length that was considered in the fencing scenario could exceed $250,000.

8.1.3 Covering of Exposed Refuse

The isolated areas where exposed refuse exists should be covered with clean fill soils and, if possible, sodded. This work could be incorporated into the ongoing park grounds maintenance program.

8.2 REMEDIAL MEASURES TO MITIGATE IMPACTS ON THE NATURAL ENVIRONMENT

The primary impact on the natural environment is the contaminant flux occurring with ground water flow through the perimeter berms directly to the Bay. While a number of alternatives may be implemented to minimize the flux via this pathway, it is believed that due to the length of shore line over which the flux occurs there are a limited number of feasible alternatives.

8.2.1 Hydraulic Containment of Leachate within Zwick's Island

Hydraulic containment consists of altering ground water flow direction artificially so that flow occurs from the Bay of Quinte towards Zwick's Island. This could possibly be achieved by continual pumping of ground water from purge wells located at various points within the waste such that the ground water level within the Island were maintained at a lower level than the Bay. The water that is removed from the purge wells could possibly be treated by a

number of methods including a treatment system installed on–site, or transported to the Belleville sewage treatment plant.

Effecting a hydraulic containment system would require a continual operating presence on the island, and periodic monitoring of effluent quality as well as ground water quality to determine system effectiveness.

Preparation of a design for such a system requires significantly more data than has been collected at present. For this reason, costing has not been prepared for this option.

8.2.2 Engineered Containment

Engineered containment consists of construction of a low permeability barrier such as a slurry trench or a sheet pile wall around the perimeter of the landfilled wastes in order to minimize the flux of ground water to the Bay of Quinte. The success of such a barrier in part depends upon the degree of connection that could be established with a low permeability horizon beneath the wastes such as clayey soils on bedrock, as well as the quantity of infiltration occurring through the cover soils over the wastes.

If the rate of infiltration occurring through existing cover soils exceeded the flux occurring through the barrier, then water levels within the wastes would gradually rise to surface, resulting in ground water flux to the Bay via surface runoff. In this case, placement of an engineered soil cover graded to shed surface water as well as some form of dewatering would be required.

Emplacement of a successful engineered barrier would result in the reduction of ground water flux to the Bay of Quinte, and consequently a reduction in contaminant flux. On–going monitoring of ground water levels would be required in order to determine the degree of effectiveness of the barrier. Periodic maintenance of the cover could also be required. It is likely that such a barrier would not be successful in totally stopping ground water flux to the Bay.

As with the hydraulic contaminant option, design of such a system requires more site specific data than has been collected at present, thus costs for this option have not been prepared.

9.0 SUMMARY AND RECOMMENDATIONS

The main findings of this study can be summarized as follows:

- ground water quality within Zwick's Island is significantly impacted by the presence of the wastes;

- surface water quality adjacent to the Zwick's Island shoreline was not observed to be significantly poorer than water further off–shore within the Bay of Quinte;

- surface water quality in the Bay of Quinte is believed to be impacted by the presence of the landfilled wastes on Zwick's Island; because of limited data this conclusion is based on the knowledge that leachate affected ground water from Zwick's Island is seeping into the Bay;

- relatively undiluted leachate is seasonally present in surface drainage ditches on Zwick's Island;

- no significant accumulations of landfill gas have been detected on Zwick's Island;

- the primary pathway for contaminant loading to the natural environment is the flux of poor quality ground water to the Bay of Quinte via a sand unit prevalent beneath the landfill's perimeter berm; this is believed to be a low concentration but persistent source of contaminant loading;

- the presence of leachate in surface drainage ditches as well as exposed refuse in some park areas pose a risk to human health, although quantification of this risk was beyond the scope of this study;

- based on the study data, it is not possible to determine whether the flux of ground water to the Bay poses a risk to human health.

Based on the findings of this study the following recommendations are presented:

- the contaminant loadings estimated in this study should be compared to loadings from other contaminant sources in the Bay of Quinte to allow determination of the relative importance of the contribution from Zwick's Island;

- the human health risk identified may be minimized by construction of security fencing around the affected drainage ditches or by possibly reconstructing the ditch so that drainage is conveyed to the Bay of Quinte via a subsurface drain, as well as by covering areas of exposed waste;

- human health scientists should review the data and conclusions presented in this report to assess whether there are any other human health issues associated with Zwick's Island;

- remedial action should be implemented, to address the human health risk posed by the presence of leachate in surface drainage ditches;

- surface and ground water quality on Zwick's Island and in the Bay of Quinte should be monitored so that a more representative data base may be established; a suggested monitoring program is presented in Appendix F;

- any redevelopment plans for Zwick's Island should address the following:

    - the possibility of encountering waste materials during the course of construction work;

    - the possibility of releasing further contaminants to the natural environment as a result of construction work; and,

    - the potential for any new structures to allow accumulation of landfill gas to combustible levels.

- routine inspection of the park grounds for areas of exposed refuse (especially along ditch slopes) should be incorporated into the routine park maintenance program.

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FIGURES

Legend

APPROXIMATE SIZE OF ZWICKS ISLAND IN 1953

INTERPRETTED AREAL EXTENT OF REFUSE PLACEMENT
(? Indicates unknown limit of refuse)

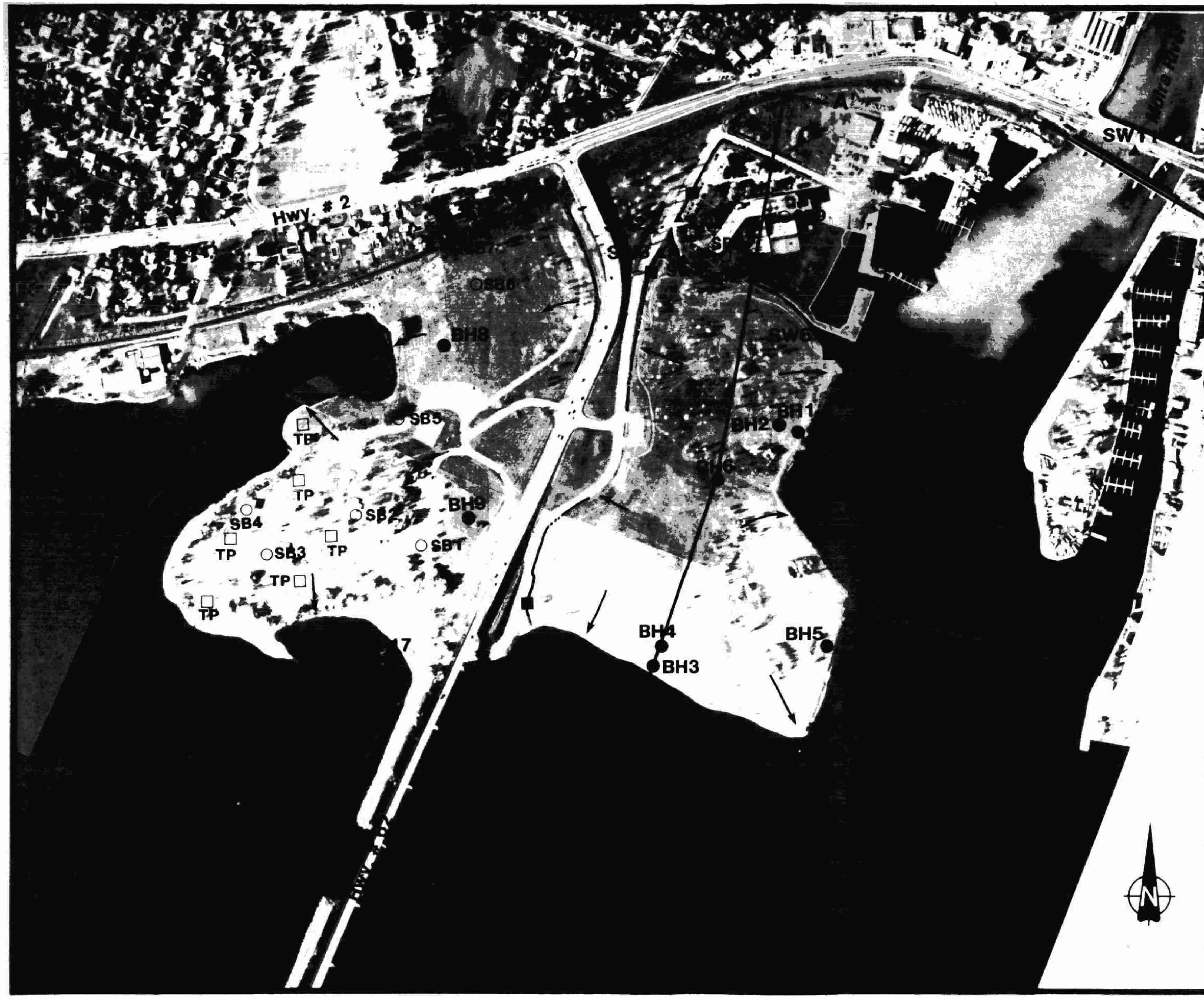
SCALE APPROX. 1:5,000

SITE FEATURES

Figure 1

ENVIRONMENTAL INVESTIGATION
OF CLOSED
ZWICKS ISLAND LANDFILL

PROJECT 90 119



LEGEND

- Surface Water
- Overland Flow Direction
- Wet Ponded Areas
- SW ▲4 Surface Water Monitoring Location
- BH ●5 Borehole and Ground Water Monitoring Location
- ⬡ Staff Gauge Location
- ■ Conductivity Measurement Locations
- ○ SB7 Shallow Hand-Augered Borehole Location
- □ TP Test Pit Excavation Location
- A' Cross – Section Profile Line (See Figure 3)

SCALE APPROX. 1:5,000

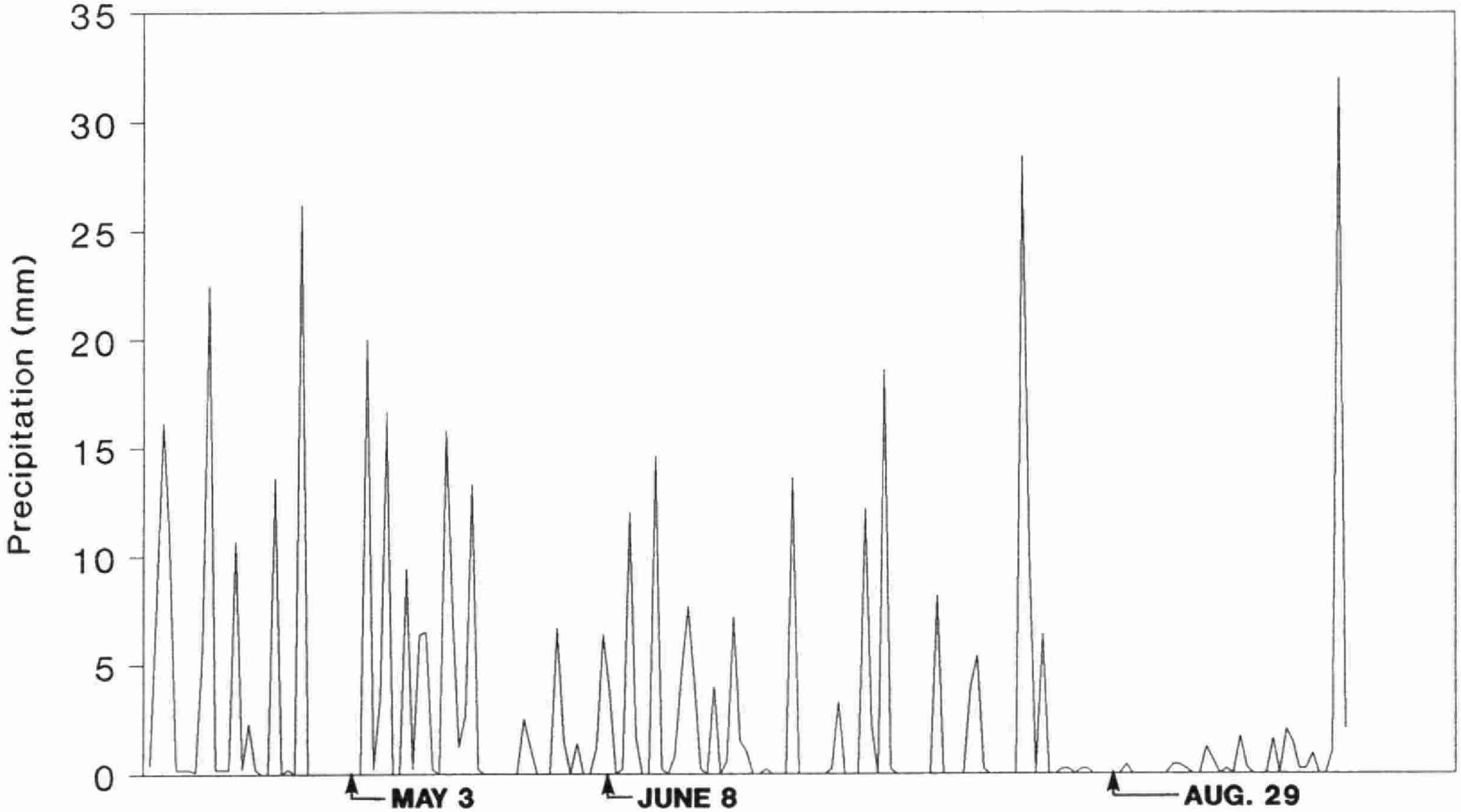
MONITORING LOCATIONS AND SURFACE DRAINAGE PATTERNS

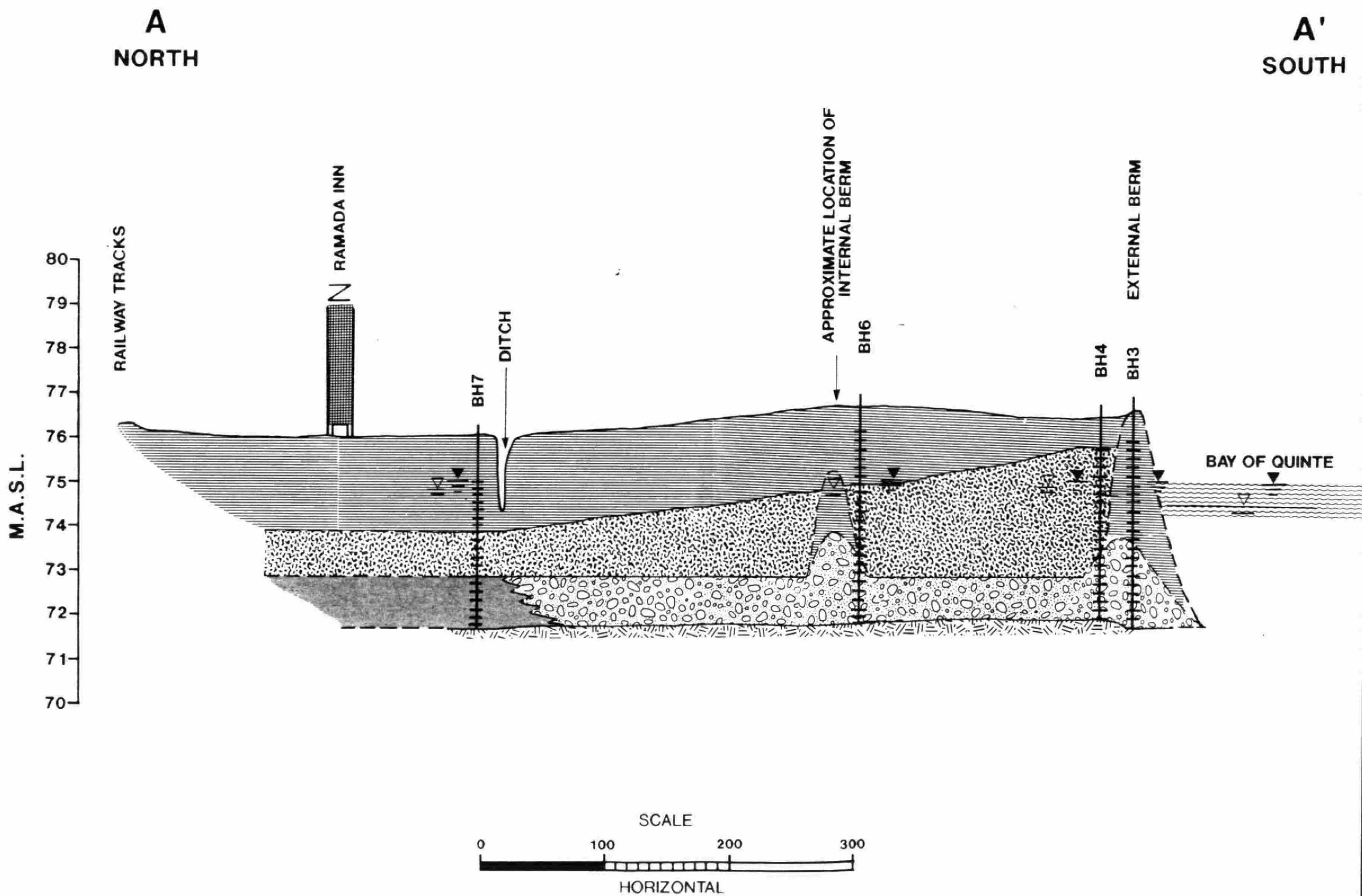
Figure 2

ENVIRONMENTAL INVESTIGATION
OF CLOSED
ZWICKS ISLAND LANDFILL

PROJECT 90 119

FIGURE 3 : Relationship of Precipitation in Belleville and Monitoring Events at Zwicks Island Landfill, 1990





Legend

- WATER LEVEL MAY 3/90
- WATER LEVEL AUG 29/90
- CLAYEY SILT / SILT CLAY FILL
- REFUSE
- SAND WITH GRAVEL
- CLAYEY SILT TILL
- PROBABLE BEDROCK
- BH4 ◄ BOREHOLE NUMBER
- ◄ PVC PIPE
- ◄ SCREENED INTERVAL

Note: Bay of Quinte water level elevation for Aug. 29, 1990 calculated from US Army Corps of Engineers Data

Specifics on the nature of the geologic materials and contact between units are only known at the borehole location. Information between boreholes is inferred only and vary from that shown.

NORTH SOUTH CROSS-SECTION

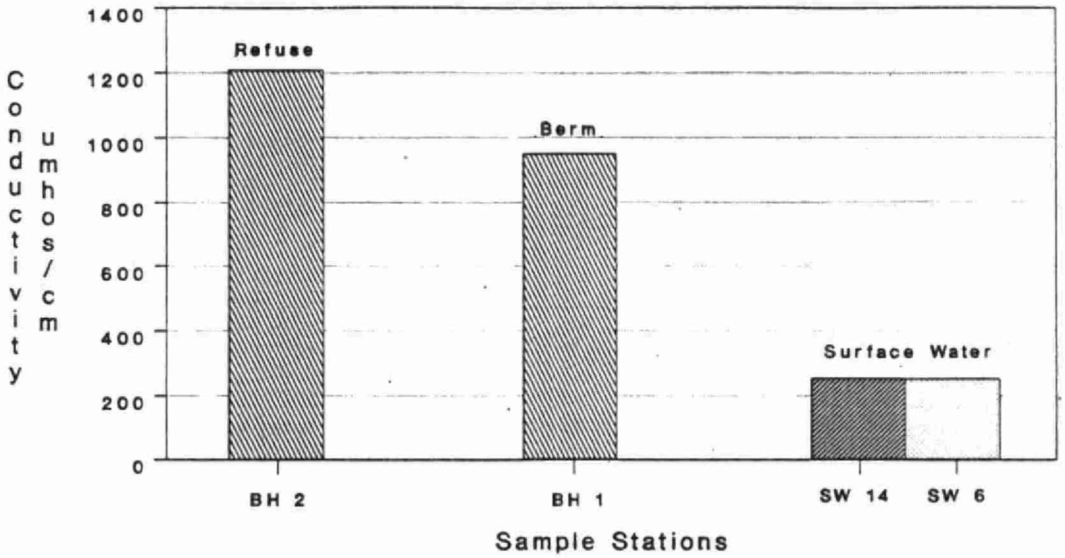
FIGURE **4**

ENVIRONMENTAL INVESTIGATION OF CLOSED ZWICKS ISLAND LANDFILL

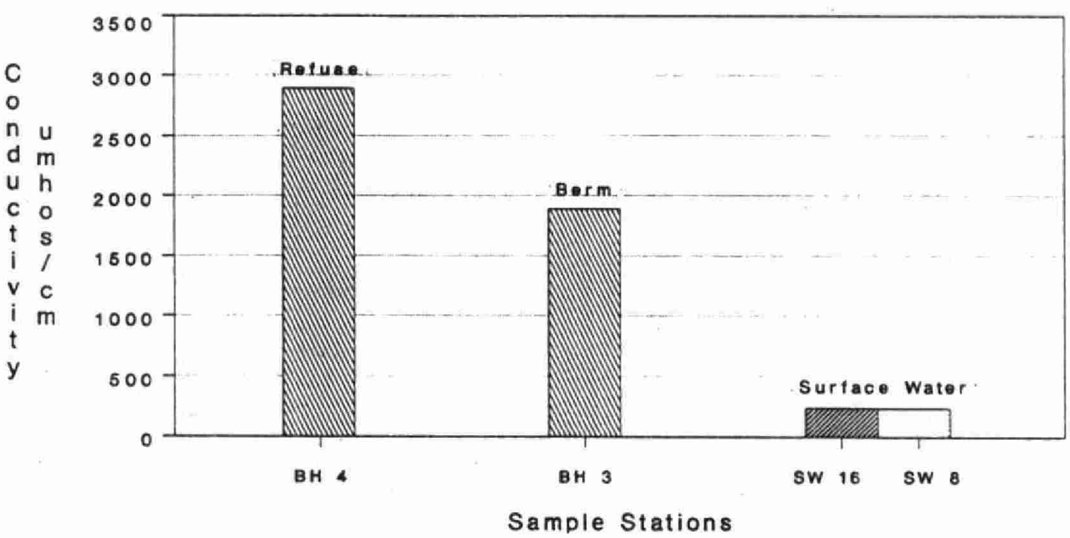
PROJECT 90-119

FIGURE 7.1 COMPARISON OF CONDUCTIVITY LEVELS
ZWICKS ISLAND LANDFILL AUGUST 29-31, 1990

A) East Area of Island



B) South Area of Island



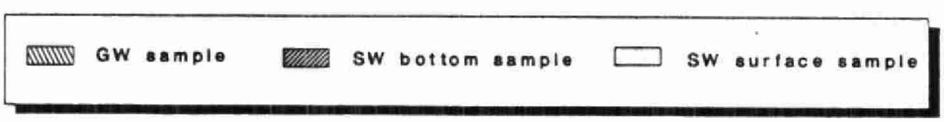


FIGURE 7.1 COMPARISON OF CONDUCTIVITY LEVELS
ZWICKS ISLAND LANDFILL AUGUST 29-31, 1990

C) South East Area of Landfill

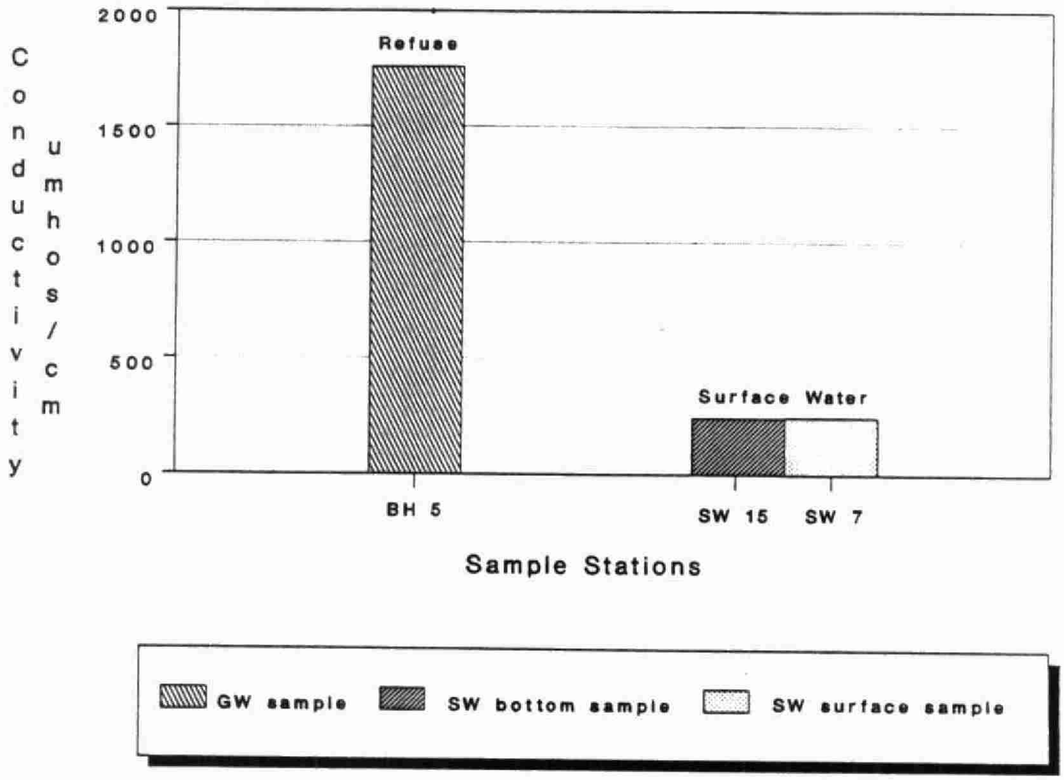
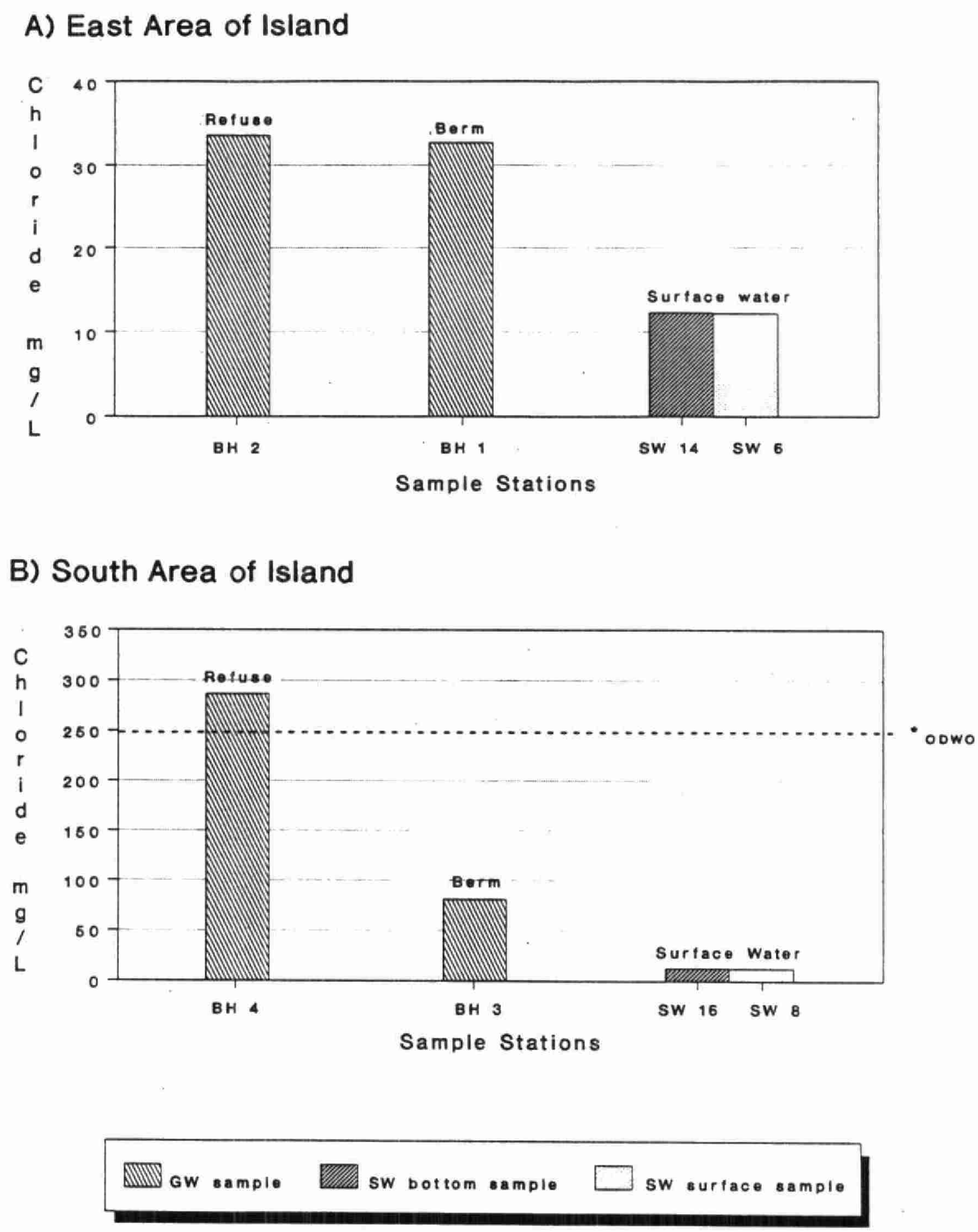


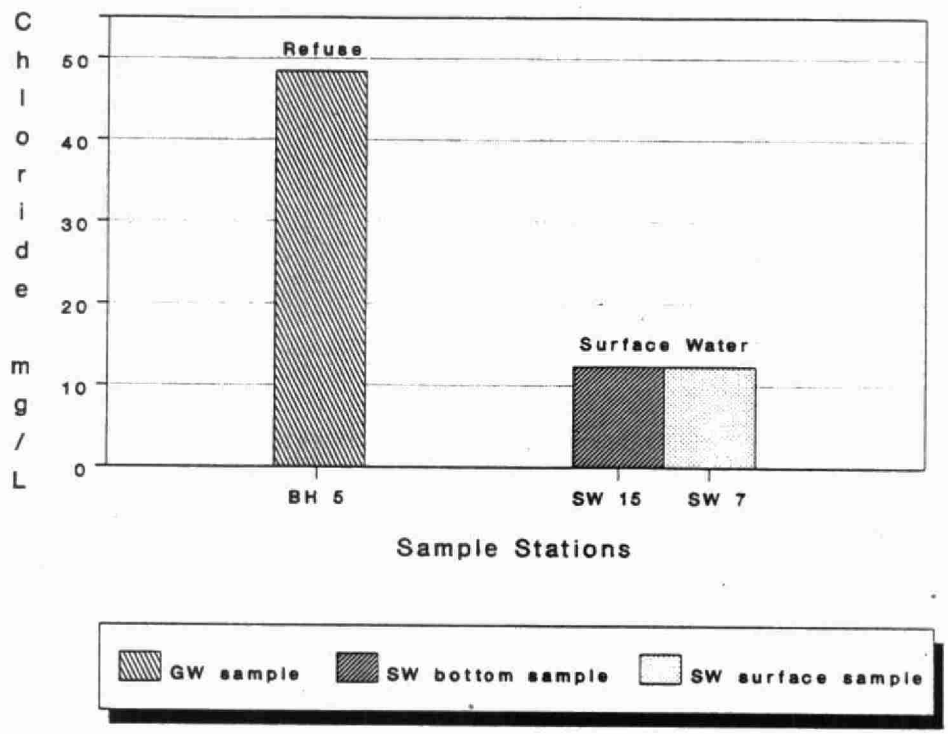
FIGURE 7.2 : COMPARISON OF CHLORIDE CONCENTRATIONS
ZWICKS ISLAND LANDFILL AUGUST 29-31, 1990



* ODWO- Ontario Drinking Water Objective is 250 mg/L.

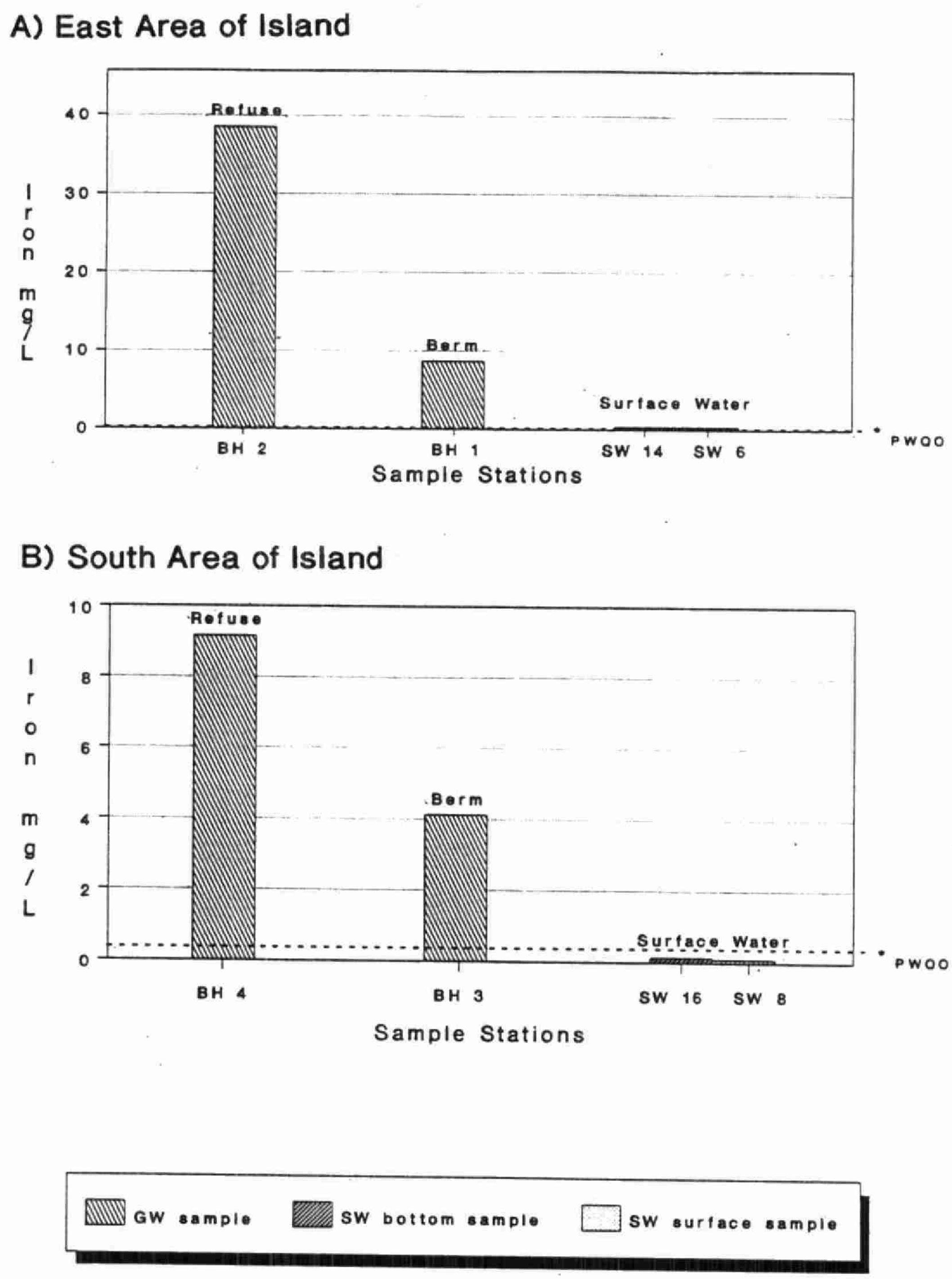
FIGURE 7.2 : COMPARISON OF CHLORIDE CONCENTRATIONS
ZWICKS ISLAND LANDFILL AUGUST 29-31, 1990

C) South East Area of Island



ODWO- Ontario Drinking Water Objective is 250 mg/L.

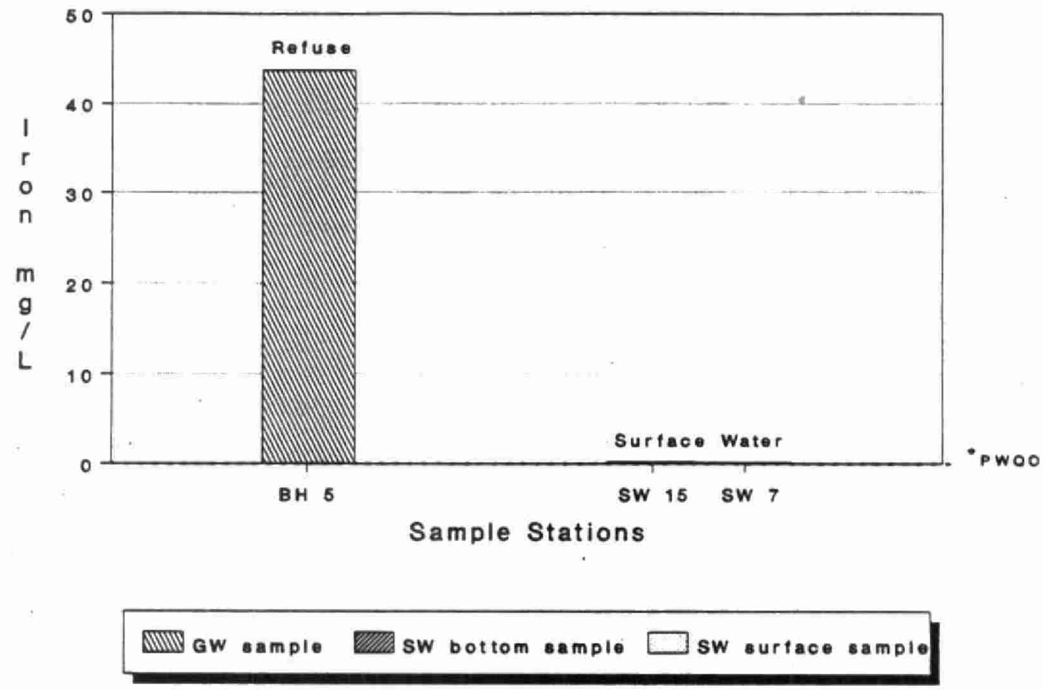
FIGURE 7.3 : COMPARISON OF IRON CONCENTRATIONS
ZWICKS ISLAND LANDFILL AUGUST 29-31, 1990



*PWQO- Provincial Water Quality Objective is 0.3 mg/L.

FIGURE 7.3 : COMPARISON OF IRON CONCENTRATIONS
ZWICKS ISLAND LANDFILL AUGUST 29-31, 1990

C) South East Area of Island

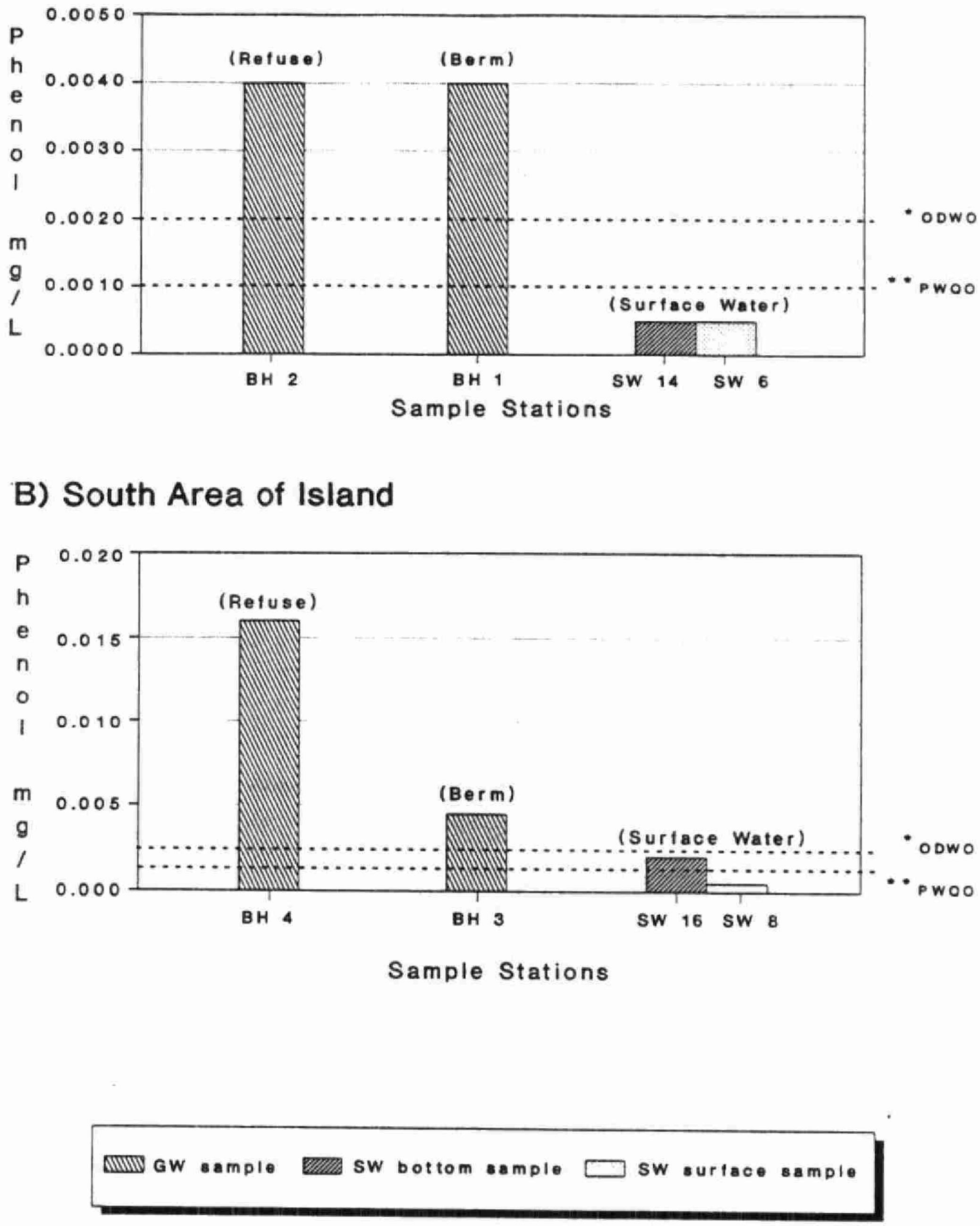


*PWQO- Provincial Water Quality Objective is 0.3 mg/L.

FIGURE 7.4 : COMPARISON OF PHENOL CONCENTRATIONS
ZWICKS ISLAND LANDFILL AUGUST 29-31, 1990

A) East Area of Island

B) South Area of Island

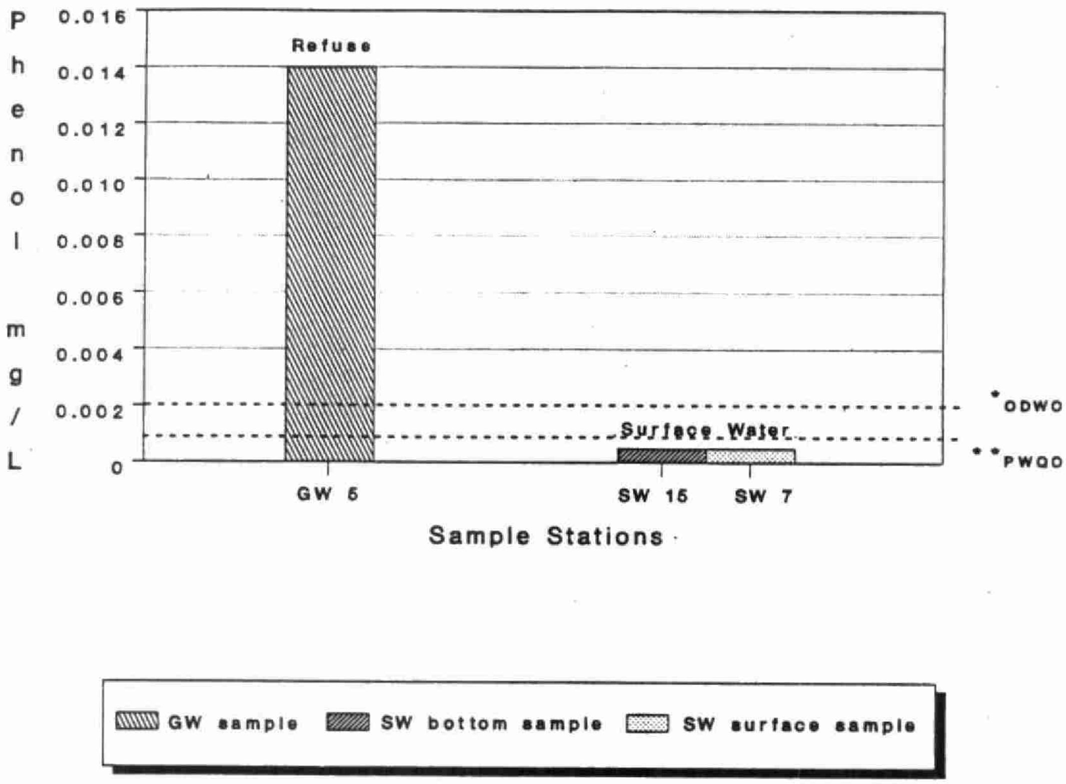


* ODWO- Ontario Drinking Water Objective is 0.002 mg/L.

** PWQO- Provincial Water Quality Objective is 0.001 mg/L.

FIGURE 7.4 : COMPARISON OF PHENOL CONCENTRATIONS
ZWICKS ISLAND LANDFILL AUGUST 29-31, 1990

C) South East Area of Island



* ODWO- Ontario Drinking Water Objective is 0.002 mg/L.

** PWQO- Provincial Water Quality Objective is 0.001 mg/L.

FIGURE 7.5 : COMPARISON OF AMMONIA CONCENTRATIONS
ZWICKS ISLAND LANDFILL AUGUST 29-31, 1900

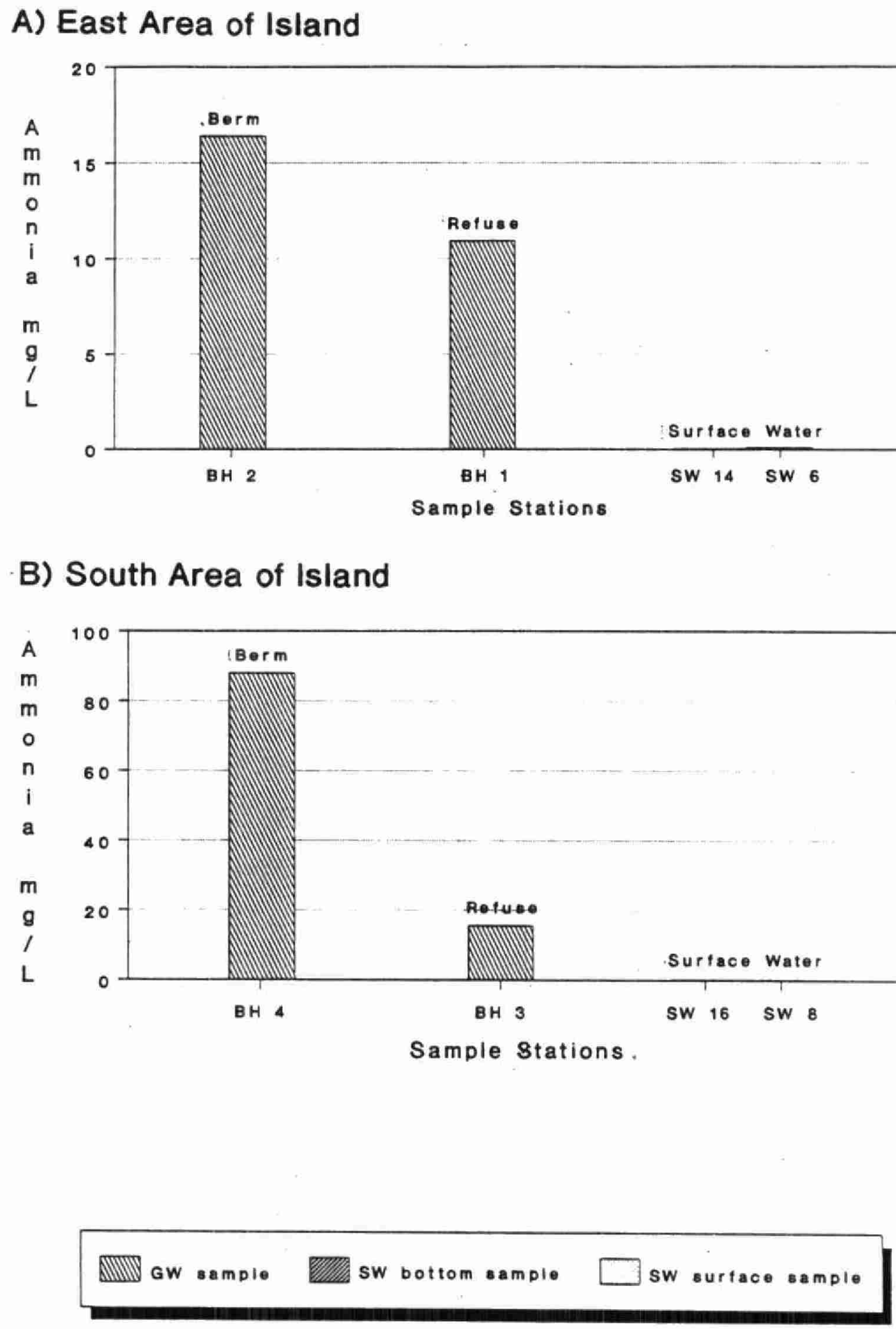


FIGURE 7.5 : COMPARISON OF AMMONIA CONCENTRATIONS
ZWICKS ISLAND LANDFILL AUGUST 29-31, 1990

C) South East Area of Island

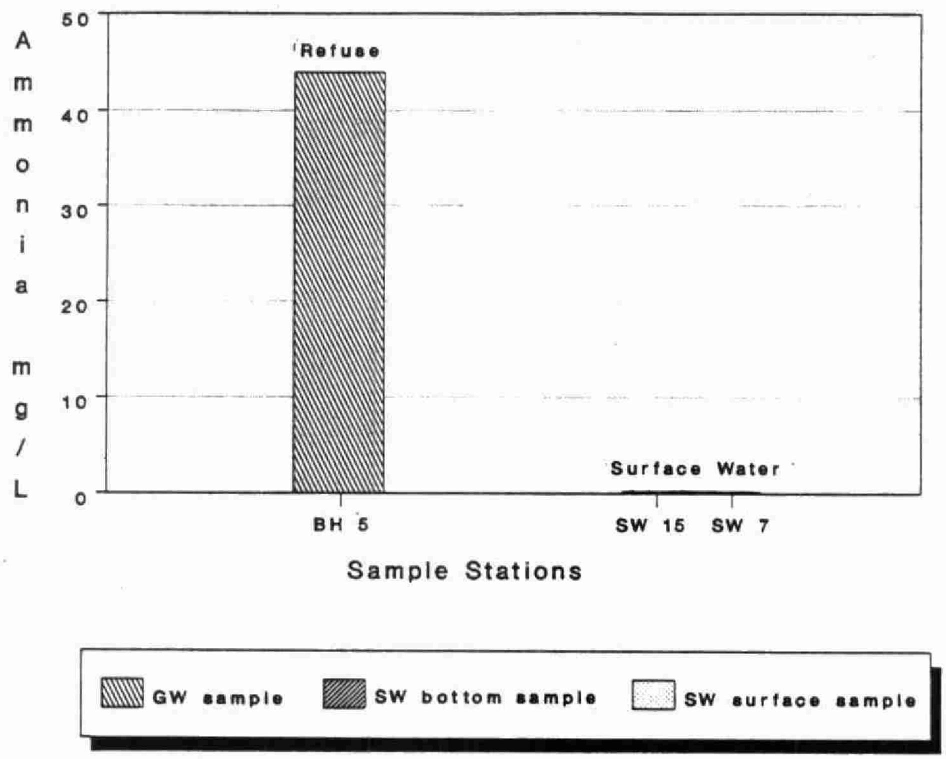


FIGURE 7.6 : COMPARISON OF DOC CONCENTRATIONS
ZWICKS ISLAND LANDFILL AUGUST 29-31, 1990

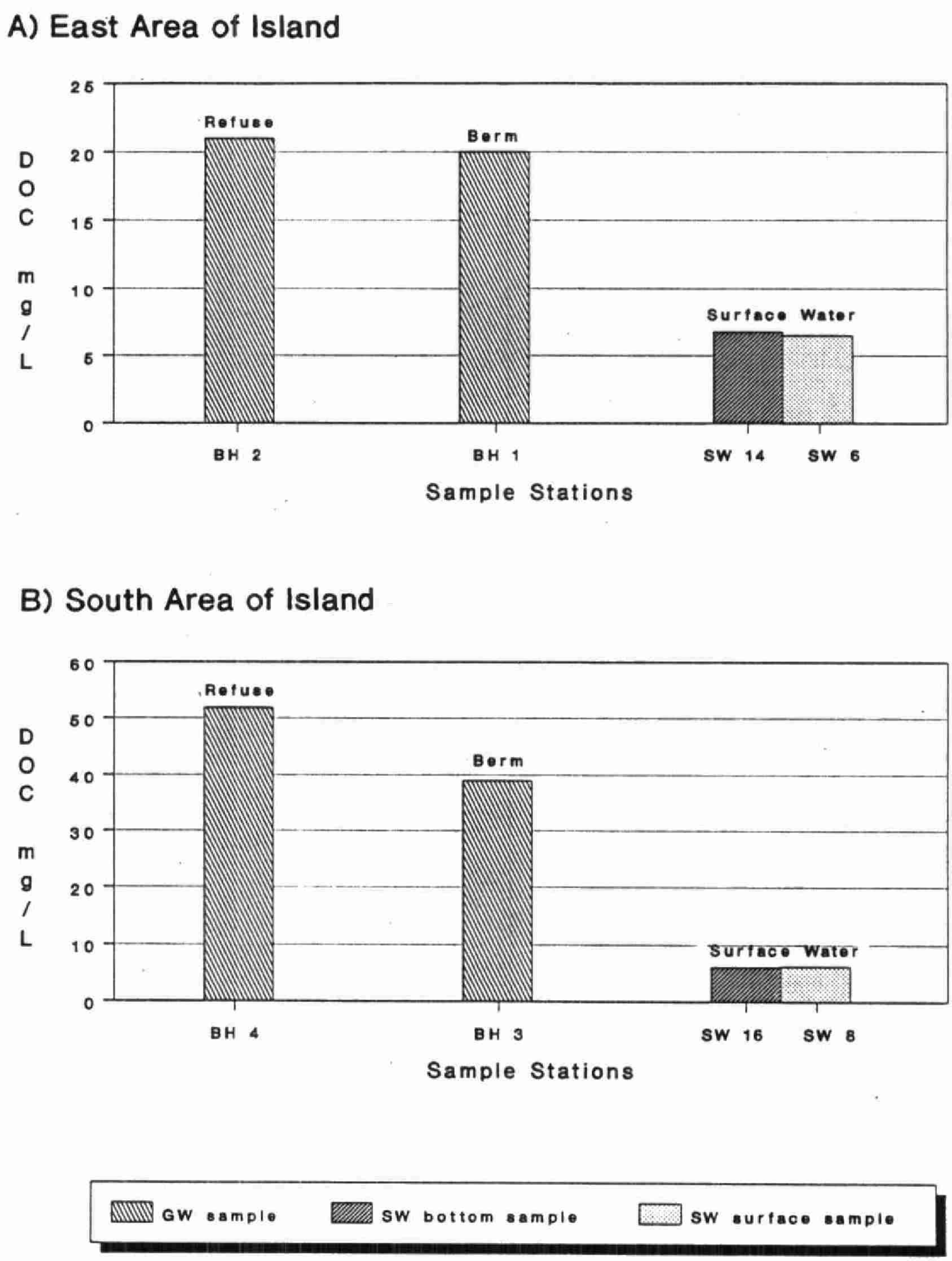


FIGURE 7.6 : COMPARISON OF DOC CONCENTRATIONS
ZWICKS ISLAND LANDFILL AUGUST 29-31, 1990

C) South East Area of Island

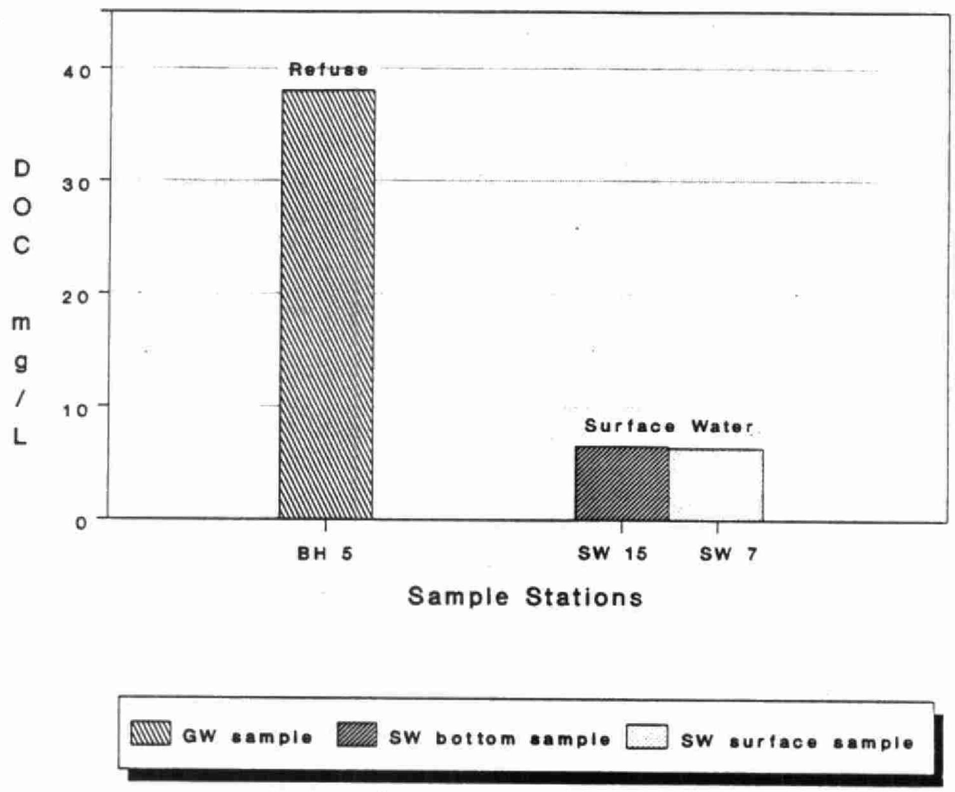


FIGURE 7.7 : COMPARISON OF TKN CONCENTRATIONS
ZWICKS ISLAND LANDFILL AUGUST 29-31, 1990

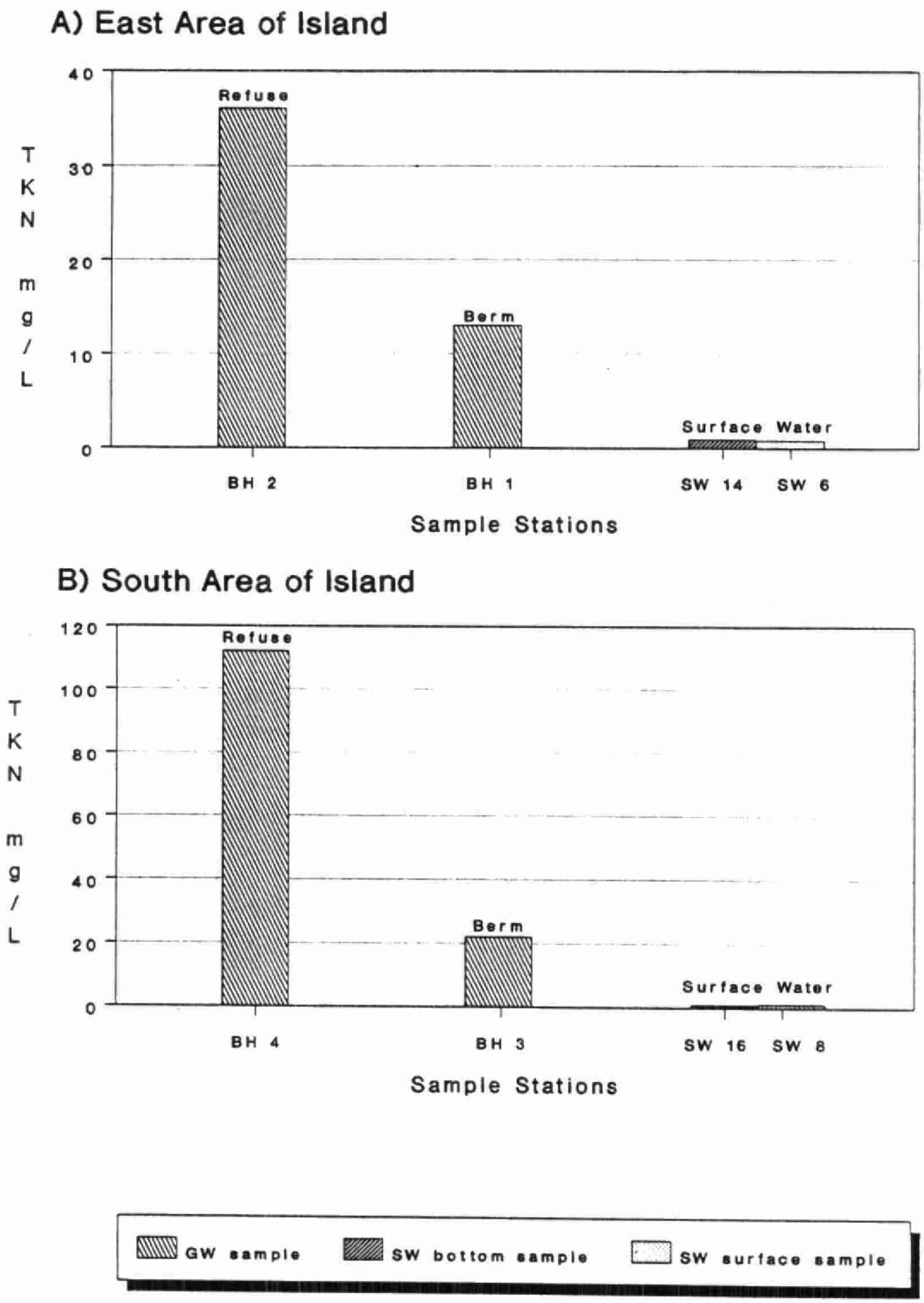


FIGURE 7.7 : COMPARISON OF TKN CONCENTRATIONS
ZWICKS ISLAND LANDFILL AUGUST 29-31, 1990

C) South East Area of Island

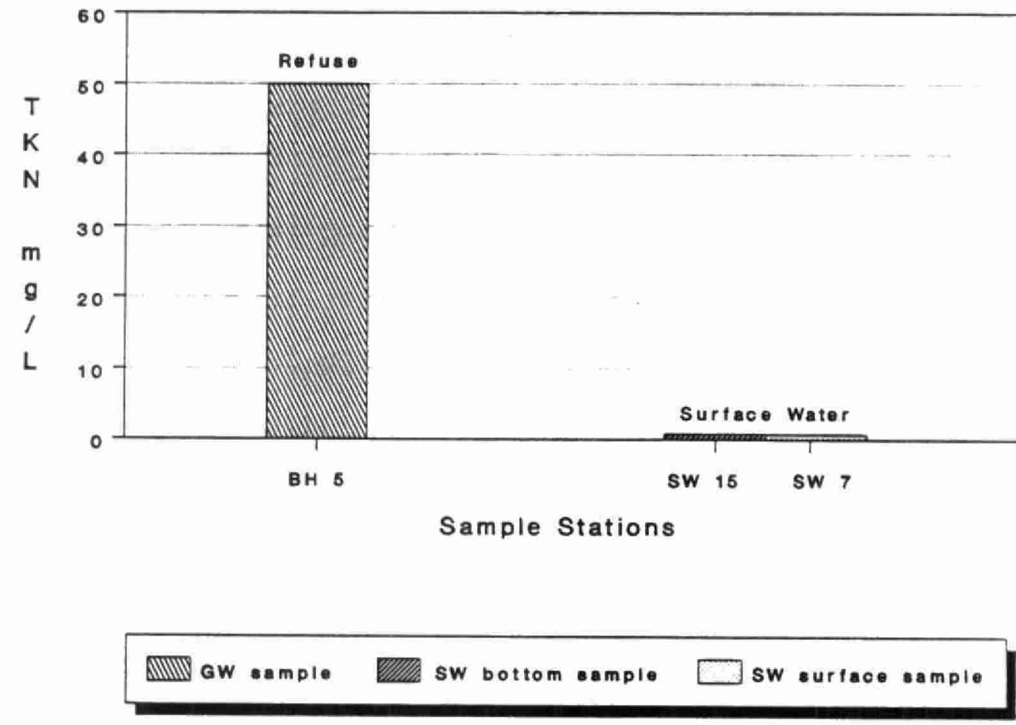


FIGURE 8.1
SURFACE WATER DOC CONCENTRATIONS
ZWICKS ISLAND LANDFILL, 1990

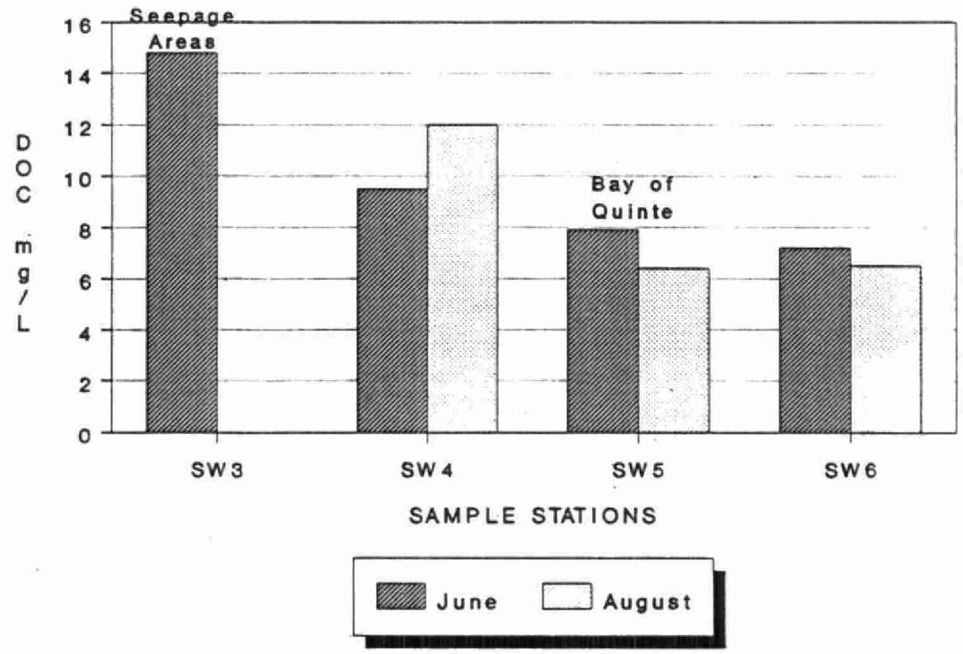


FIGURE 8.2
SURFACE WATER CONDUCTIVITY LEVELS
ZWICKS ISLAND LANDFILL, 1990

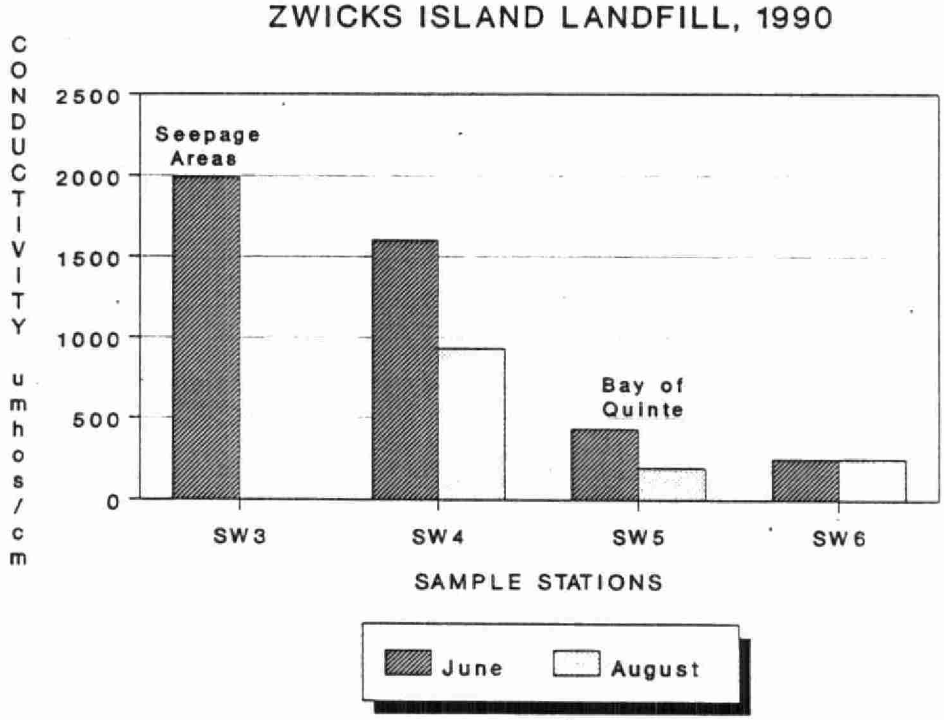


FIGURE 8.3
SURFACE WATER CHLORIDE CONCENTRATIONS
ZWICKS ISLAND LANDFILL, 1990

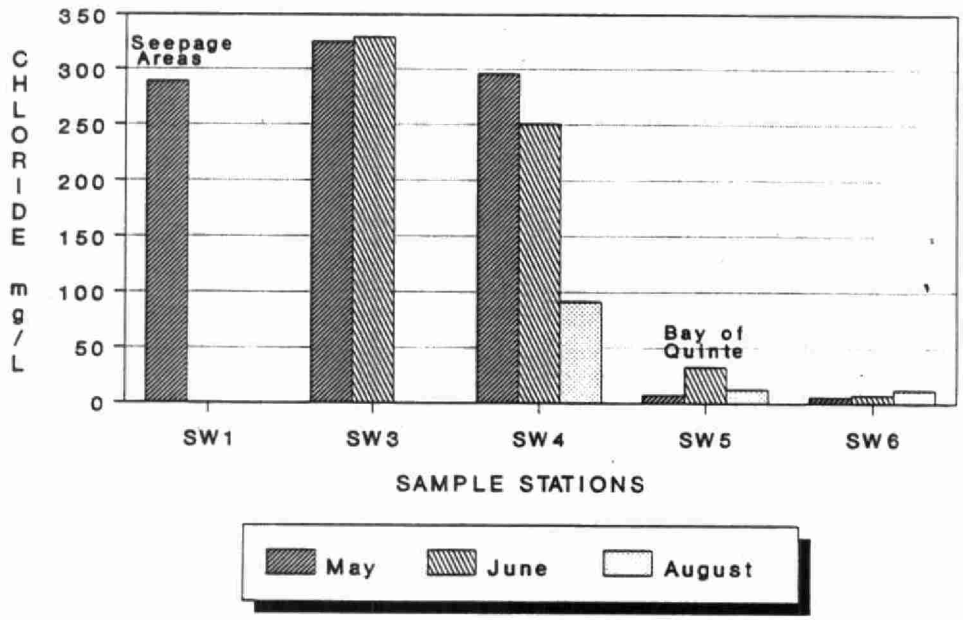


FIGURE 8.4
SURFACE WATER AMMONIA CONCENTRATIONS
ZWICKS ISLAND LANDFILL, 1990

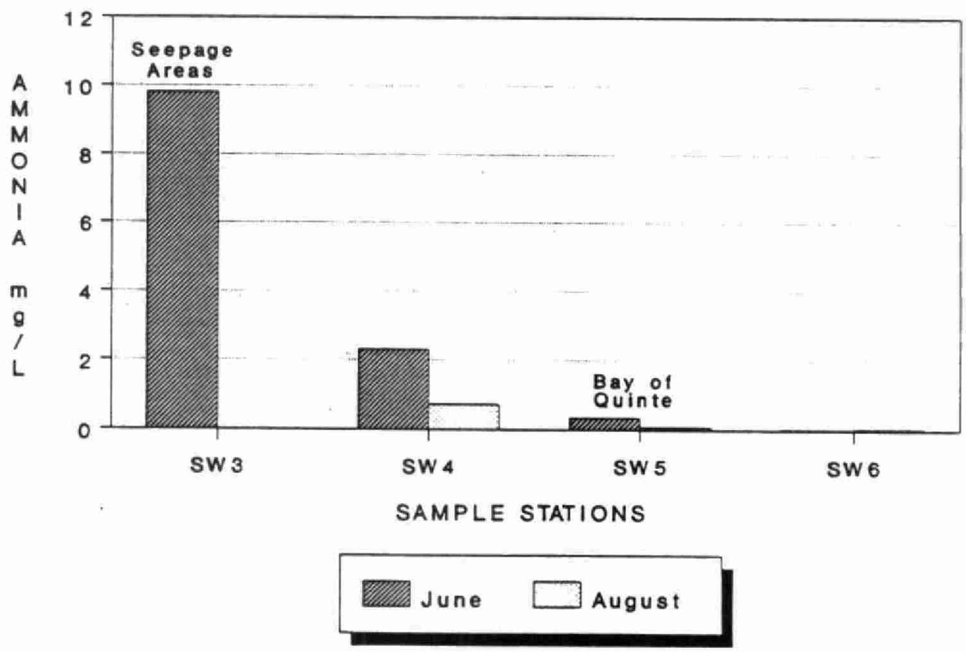
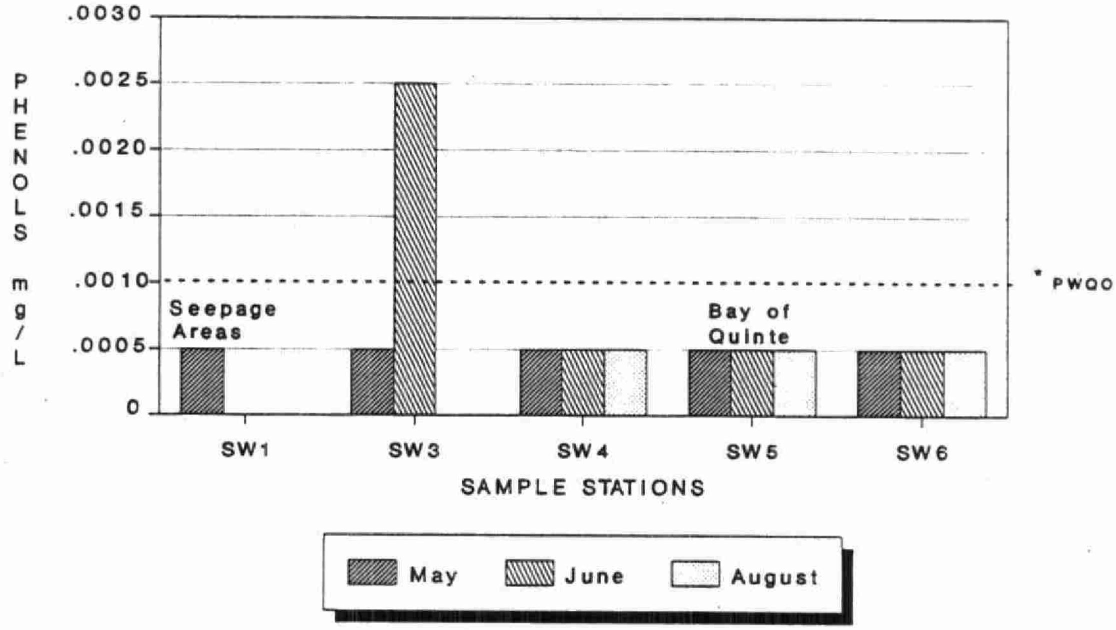
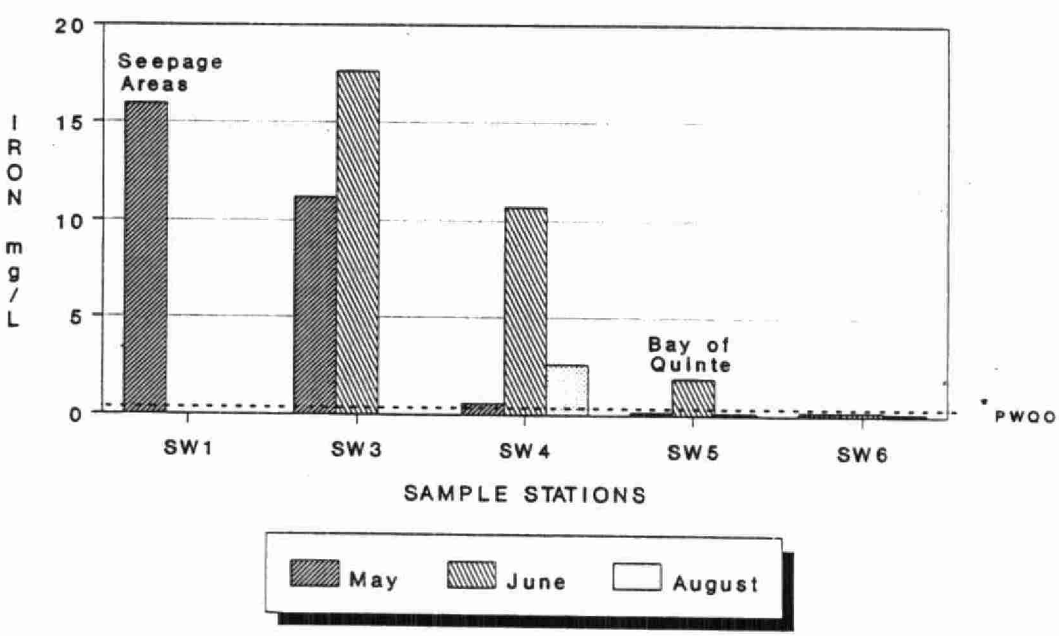


FIGURE 8.5
SURFACE WATER PHENOL CONCENTRATIONS
ZWICKS ISLAND LANDFILL, 1990



*PWQO- Provincial Water Quality Objective for phenol is .001 mg/L.

FIGURE 8.6
SURFACE WATER IRON CONCENTRATIONS
ZWICKS ISLAND LANDFILL, 1990



* PWQO- Provincial Water Quality Objective for iron is 0.30 mL

Figure 9.1: SURFACE WATER DOC CONCENTRATIONS
Comparison of Bottom and Surface Samples
Zwicks Island Landfill, August 1990

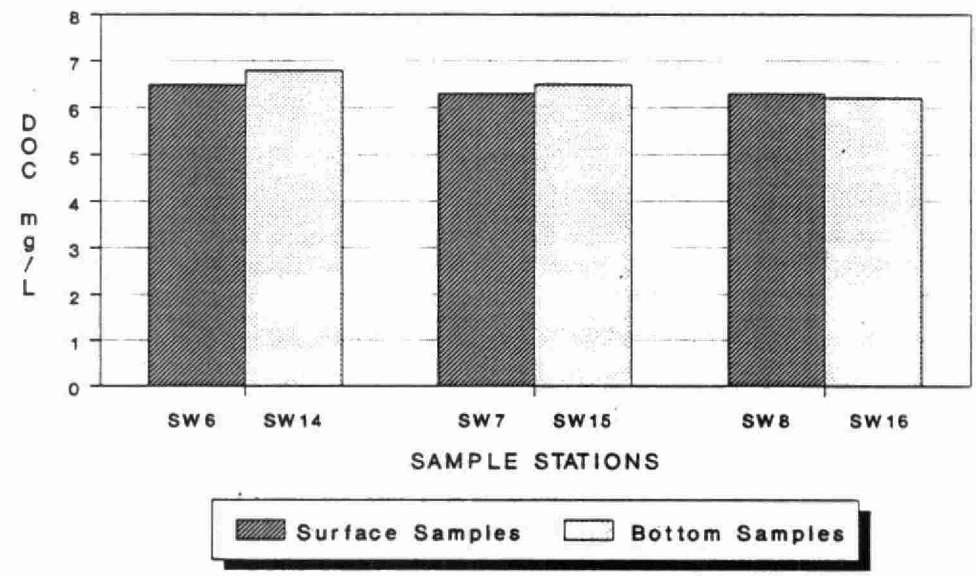


Figure 9.2: SURFACE WATER CODUCTIVITY LEVELS
Comparison of Bottom and Surface Samples
Zwicks Island Landfill, August 1990

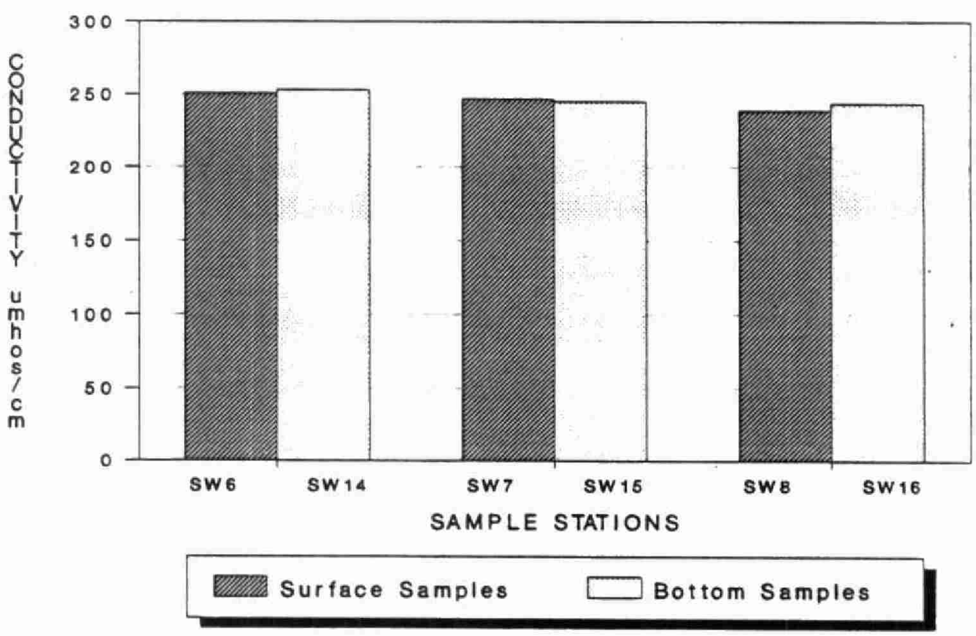


Figure 9.3: SURFACE WATER CHLORIDE CONCENTRATIONS
Comparison of Bottom and Surface Samples
Zwicks Island Landfill, August 1990

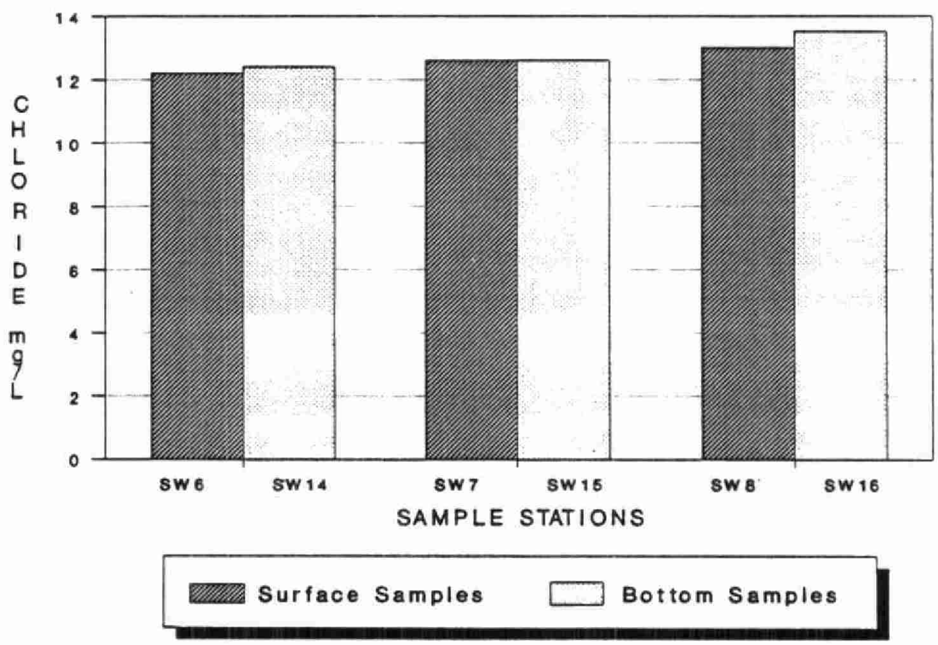


Figure 9.4: SURFACE WATER AMMONIA CONCENTRATIONS
Comparison of Bottom and Surface Samples
Zwicks Island Landfill, August 1990

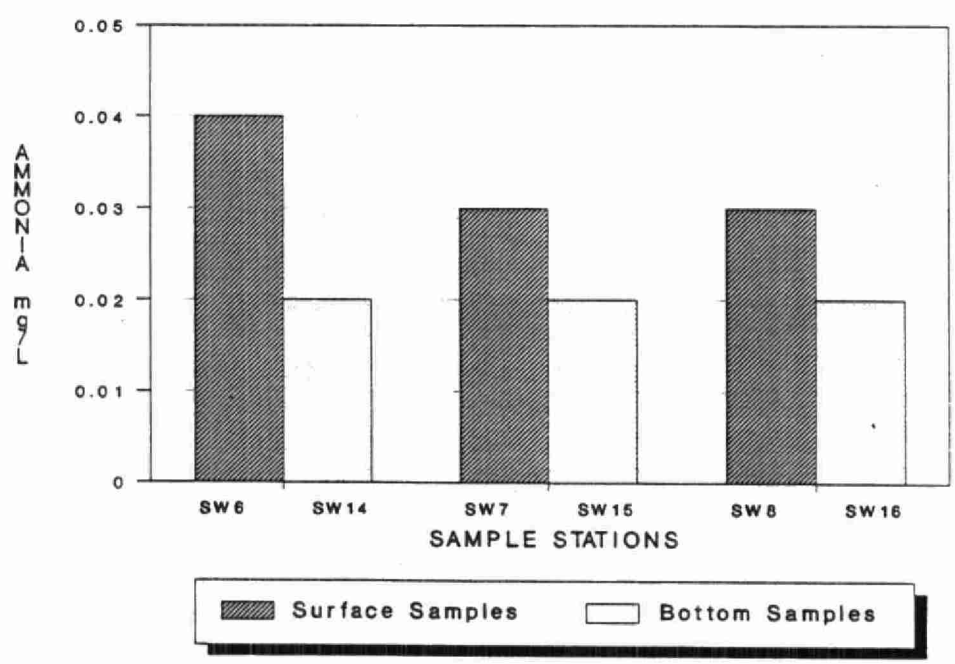
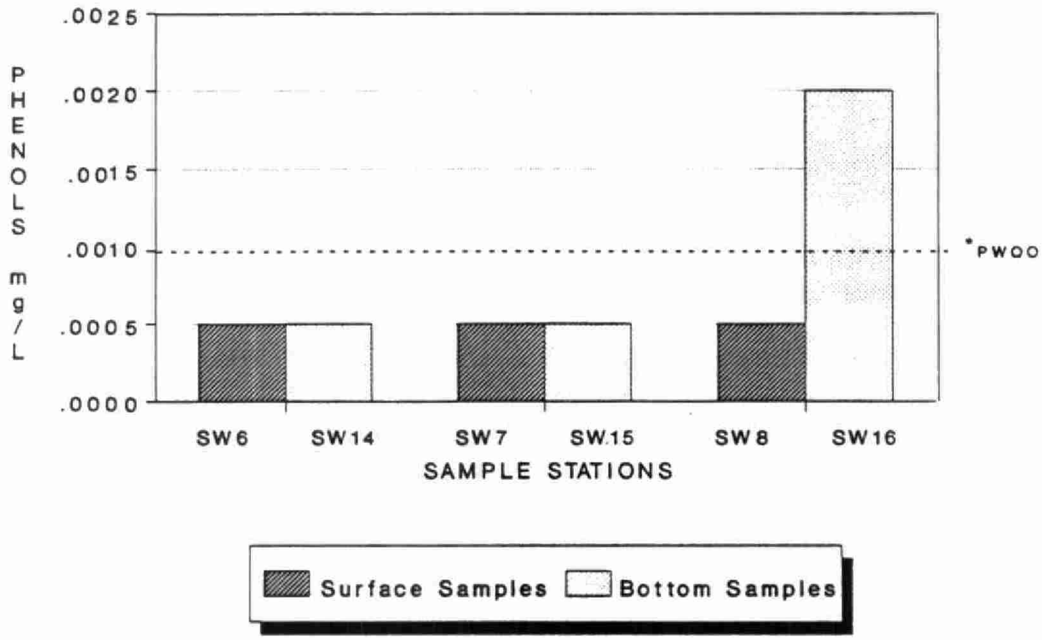
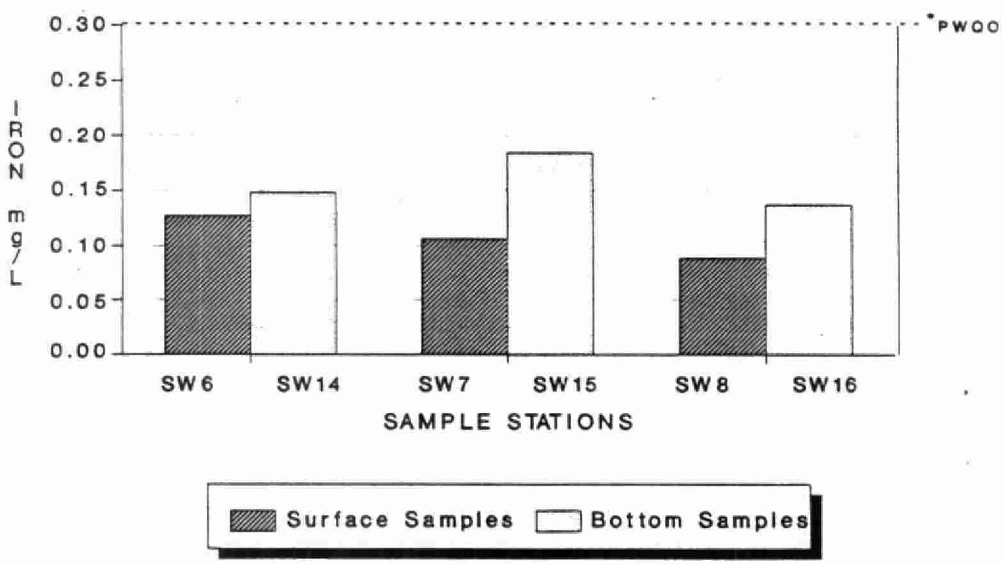


Figure 9.5: SURFACE WATER PHENOL CONCENTRATIONS
Comparison of Bottom and Surface Samples
Zwicks Island Landfill, August 1990



* PWQO- Provincial Water Quality Objective for phenols is .001 mg/L.

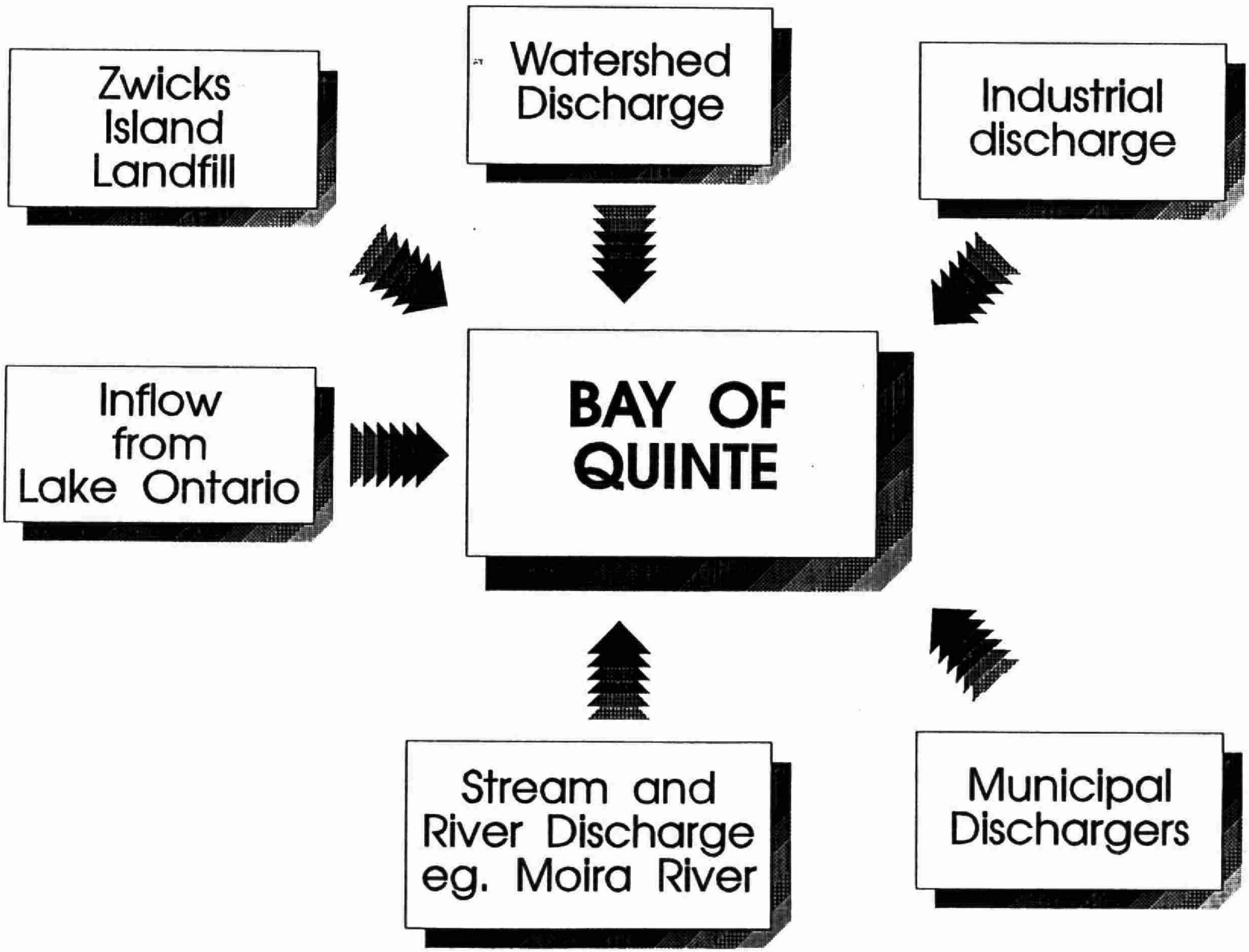
Figure 9.6: SURFACE WATER IRON CONCENTRATIONS
Comparison of Bottom and Surface Samples
Zwicks Island Landfill, August 1990



* PWQO- Provincial Water Quality Objective for Iron is 0.30 mg/L.

FIGURE 10

Contaminant sources to the Bay of Quinte



TABLES

TABLE 1: SURFACE WATER QUALITY RESULTS FOR SELECTED WATER QUALITY VARIABLES

STATION	DATE		CONDUCTIVITY umhos/cm	CHLORIDE mg/L	IRON mg/L	TKN mg/L	pH	UNIONIZED AMMONIA mg/L	DOC mg/L	PHENOLS mg/L
		PWQO			0.3		6.5-8.5	0.02		0.001
		CWQG			0.3				2-10	
		NER			<0.5	<0.5				
SW1	03-May-90		1675	289.0	15.90	21.40	6.8			< 0.0005
	08-Jun-90									
	29-Aug-90									
SW2	03-May-90		1025	103.0	1.01	1.71	7.5			0.0080
	08-Jun-90									
	29-Aug-90									
SW3	03-May-90		1700	325.0	11.20	17.70	7.2			< 0.0005
	08-Jun-90		2050	329.0	17.60	18.00	7.1	0.026	14.8	0.0025
	29-Aug-90									
SW4	03-May-90		1500	296.0	0.61	5.10	7.3			< 0.0005
	08-Jun-90		1500	251.0	10.70	3.80	7.3	0.020	9.5	< 0.0005
	29-Aug-90		600	90.9	2.57	2.90	7.2	0.003	12.0	< 0.0005
SW5	03-May-90		205	7.3	0.16	0.61	8.0			< 0.0005
	08-Jun-90		345	32.1	1.90	0.89	7.2	0.001	7.9	< 0.0005
	29-Aug-90		135	12.4	0.12	0.67	9.4	0.058	6.4	0.0005
SW6	03-May-90		190	5.9	0.19	0.53	8.2			< 0.0005
	08-Jun-90		160	7.5	0.20	0.53	7.8	0.001	7.2	< 0.0005
	29-Aug-90		160	12.2	0.13	0.83	8.2	0.002	6.5	< 0.0005
SW7	03-May-90		195	5.7	0.20	0.55	8.1			< 0.0005
	08-Jun-90		160	8.6	0.56	0.45	8.0	0.001	6.8	< 0.0005
	29-Aug-90		160	12.4	0.11	0.79	8.4	0.005	6.3	< 0.0005
SW8	03-May-90		235	9.6	0.29	0.58	8.4			< 0.0005
	08-Jun-90		170	8.1	0.21	0.44	8.0	0.002	6.7	< 0.0005
	29-Aug-90		140	13.0	0.09	0.98	8.6	0.005	6.3	< 0.0005
SW9	03-May-90		240	14.0	0.52	0.88	7.9			< 0.0005
	08-Jun-90		173	12.2	0.15	0.54	8.0	0.005	5.5	< 0.0005
	29-Aug-90		160	16.5	0.25	1.02	8.6	0.021	6.5	< 0.0005
SW11	29-Aug-90		210	10.1	0.08	0.65	8.2	0.001	7.0	< 0.0005
SW12	29-Aug-90		175	12.7	0.16	0.87	7.5	0.000	6.3	< 0.0005

PWQO Provincial Water Quality Objectives (MOE, 1984)
CWQG Canadian Water Quality Guidelines (Environment Canada, 1987)
NER Natural Evironmental Range (MOE, 1979)
Value exceeds PWQO
Value exceeds CWQG and/or NER

TABLE 1: SURFACE WATER QUALITY RESULTS FOR SELECTED WATER QUALITY VARIABLES

STATION	DATE		CONDUCTIVITY umhos/cm	CHLORIDE mg/L	IRON mg/L	TKN mg/L	pH	UNIONIZED AMMONIA mg/L	DOC mg/L	PHENOLS mg/L
		PWQO			0.3		6.5–8.5	0.02		0.001
		CWQG			0.3				2–10	
		NER			<0.5	<0.5				
SW13	29–Aug–90		180	13.0	0.09	1.03	8.3	0.003	6.5	< 0.0005
SW14	29–Aug–90		160	12.3	0.15	0.94	7.8	0.001	6.8	< 0.0005
SW15	29–Aug–90		140	12.4	0.18	0.81	8.6	0.003	6.5	< 0.0005
SW16	29–Aug–90		140	13.4	0.14	0.93	8.7	0.006	6.2	< 0.0005
SW17	29–Aug–90		160	12.8	0.01	0.92	8.5	0.003	6.0	< 0.0005

PWQO Provincial Water Quality Objectives (MOE, 1984)
CWQG Canadian Water Quality Guidelines (Environment Canada, 1987)
NER Natural Evironmental Range (MOE, 1979)
Value exceeds PWQO
Value exceeds CWQG and/or NER

TABLE 2: ESTIMATED LOADINGS OF SELECTED PARAMETERS FROM GROUND WATER FLOW INTO THE BAY OF QUINTE.

LOCATION	GROUND WATER FLUX TO BAY	CHLORIDE CONCENTRATION	CHLORIDE LOADING	IRON CONCENTRATION	IRON LOADING	PHENOL CONCENTRATION	PHENOL LOADING	AMMONIA CONCENTRATION	AMMONIA LOADING
BH2	MAY 2.6 L/d/m²	MAY 22.3 mg/L	58.0 mg/d/m²	MAY 43.7 mg/L	113.6 mg/d/m²	MAY 0.006 mg/L	0.016 mg/d/m²		
	JUNE 6.0 L/d/m²							JUNE 30.0 mg/L	180 mg/d/m²
	AUGUST 6.0 L/d/m²	AUGUST 33.6 mg/L	201.6 mg/d/m²	AUGUST 38.5 mg/L	231.0 mg/d/m²	AUGUST 0.004 mg/L	0.024 mg/d/m²	AUGUST 16.4 mg/L	98.4 mg/d/m²
BH4	MAY 6.0 L/d/m²	MAY 202.0 mg/L	1212.0 mg/d/m²	MAY 41.6 mg/L	249.6 mg/d/m²	MAY 0.03 mg/L	0.18 mg/d/m²		
	JUNE 6.9 L/d/m²							JUNE 93.0 mg/L	641.7 mg/d/m²
	AUGUST 10.0 L/d/m²	AUGUST 286.0 mg/L	2860.0 mg/d/m²	AUGUST 9.16 mg/L	91.6 mg/d/m²	AUGUST 0.016 mg/L	0.16 mg/d/m²	AUGUST 88.0 mg/L	880.0 mg/d/m²
BH8	MAY 8.6 L/d/m²	MAY 225.0 mg/L	1935.0 mg/d/m²	MAY 42.2 mg/L	362.9 mg/d/m²	MAY 0.0025 mg/L	0.022 mg/d/m²		
	JUNE 7.8 L/d/m²							JUNE 14.0 mg/L	109.2 mg/d/m²
	AUGUST 8.6 L/d/m²	AUGUST 188.0 mg/L	1616.8 mg/d/m²	AUGUST 28.5 mg/L	245.1 mg/d/m²	AUGUST 0.007 mg/L	0.06 mg/d/m²	AUGUST 33.0 mg/L	283.8 mg/d/m²
TOTAL FLUX FROM ZWICK'S ISLAND	MAY 31,008 L/d	MAY AVG = 149.8 mg/L	4.6 Kg/d	MAY AVG = 42.5 mg/L	1.3 Kg/d	MAY AVG = 0.013 mg/L	0.0004 Kg/d		
	JUNE 37,536 L/d							JUNE AVG = 45.7 mg/L	1.7 Kg/d
	AUGUST 39,360 L/d	AUGUST AVG = 169.2 mg/L	6.7 Kg/d	AUGUST AVG = 25.4 mg/L	1.0 Kg/d	AUGUST AVG = 0.009 mg/L	0.0004 Kg/d	AUGUST AVG = 45.8 mg/L	1.8 Kg/d

APPENDIX A

FIELD METHODOLOGIES

FIELD METHODOLOGIES

A.1 SUBSURFACE INVESTIGATIONS

In April, 1990, the field program for the environmental assessment of the closed Zwick's Island Landfill site was initiated. The program included the following tasks:

- drilling of boreholes and collection of soil samples;
- installation of ground water monitors and measurement of ground water levels to establish ground water flow directions and gradients;
- field slug testing to obtain hydraulic conductivity readings;
- collection of ground water samples from each monitor for laboratory chemical analyses; and
- hand augering of shallow boreholes for combustible gas readings.

Each of these tasks are described in the following sections.

Drilling of Boreholes and Collection of Soil Samples

On April 5 and 6, 1990 a truck mounted soils drill rig was used to drill nine boreholes on Zwick's Island. The borehole locations are shown in Figure 2. Hollow stem augers (95 mm internal diameter) were used to advance the boreholes to depths ranging from 3.6 to 4.5 m below ground surface. Soil samples were collected at regular intervals using a 0.5 m long split–spoon sampler. The number of blows required to drive the spoon for each 0.15 m of its length was recorded. A photo–ionizing volatile vapour detector was used to monitor the length of each sample and the resultant volatile vapour reading recorded. The samples were stratigraphically logged in the field by the supervising geologist. Borehole logs are presented in Appendix B.

Because the nature of the landfilled materials were unknown, numerous precautions were taken to ensure the safety of the field crew. In addition to standard safety gear (hard hat and safety boots) full coverage coveralls, gloves and an air support system was used. The system consisted of an air compressor which supplied air to each of the geologist, the driller, and helper via a full–face coverage mask.

The air support system was placed up–wind of the work area and supplied clean air into the face masks so that potentially hazardous fumes from the borehole would not affect the field crew. Since the site is used as a public park, the area around the borehole being drilled was cordoned off with fluorescent pylons and flagging tape for an area approximately 10 m around the borehole. Ambient air readings at the boundary of the flagged off area were periodically checked with the photo–ionizing detector to ensure that no volatile vapours were present. Prior to the commencement of drilling each borehole, the sod for a square area 0.6 m of a side was carefully removed and replaced upon completion of drilling.

Prior to the commencement of drilling at each borehole location, the sod within a square area 0.6 m on a side around the borehole was removed and set aside. Plastic sheeting was then placed adjacent to the borehole. All cuttings brought to surface prior to drilling where placed on the plastic sheeting and subsequently placed in sealable steel drums. Upon completion of work at that location, the plastic sheeting was disposed of in the drums, and the sod replaced around the borehole. This step was taken to ensure that any potentially contaminated cuttings brought to surface during the drilling operations would not contact the existing ground, and also to restore the site, as much as possible, to its original conditions.

Field crew members actively handling the soil samples were disposable vinyl gloves which were discarded after each sample. Waste materials generated from the drilling operation were collected in metal drums and sealed. These were stored on–site in a locked dumpster. Upon completion of the field work, the waste in the drums was inspected by Doug Graham, Ministry of the Environment, Belleville, and disposed of under his direction.

Installation of Ground Water Monitors

A ground water monitoring well was installed in each of the nine boreholes drilled. These were constructed from pre–washed 50 mm diameter, schedule 40, flush–jointed PVC pipe.

The screened section of the monitors consisted of a 3 m length of machine slotted pipe. A filter sand pack was installed around the screened section of the monitor. A bentonite seal was placed above the screened zone. A lockable protective steel casing was installed above ground around the monitor pipe. Monitor details are presented in Appendix B.

All monitors were surveyed for vertical elevation control with respect to geometric datum.

Field Slug Testing

Upon completion of the monitor installations, field slug testing was undertaken to measure the hydraulic conductivities in several of the monitors. A 1.5 by 0.03 metre steel slug was dropped into the monitor pipe displacing a known volume of water. Immediately upon the injection of the slug, a series of water level readings were recorded using an electronic water level probe to record the amount of time necessary for the water level to return to static conditions. The slug and the water level probe tip were rinsed with distilled water prior to and following measurements in each well to avoid cross–contamination.

In the office, the data was analyzed using a specialized Bower and Rice slug test program for standpipes. The results of these analyses are presented in Appendix C.

Ground Water Sampling and Analysis

Monitoring wells were allowed to equilibrate for a period of approximately 3 weeks before the first set of ground water samples were collected. Water levels in each well were measured and the wells developed in preparation for recovery of ground water samples.

Three separate sampling runs of the nine monitors were conducted. These occurred in May, June and August, 1990. For each sampling run, each monitor was developed by removing 3 well bore volumes using a Nadon check valve and polyethylene tubing. Check valves and tubing were dedicated to each monitor. Samples were collected and analyzed for volatile priority pollutants, TKN, general water quality (RCAP), phenols and metals. The results of these analyses are presented in the Appendix. Sample bottles and laboratory analyses were supplied by Barringer Laboratories in Mississauga. The water samples were packed in ice in an insulated chest during shipment to the laboratory.

Combustible Gas Monitoring

A portable combustible JW gas sniffer was used to test nine shallow hand augered holes penetrated through potential area of waste. Due to the rocky nature of the subsurface materials, hand augered holes ranged from 0.01 to 0.9 m in depth. The locations of the hand augered holes are shown in Figure 2. The results of the gas monitoring are presented in Appendix C.

Excavation of Test Pits

A series of 6 shallow test pits were excavated on the west of Zwick's Island in order to assess the areal limit of landfill refuse placement in that area.

Excavation was carried out using a rubber tired backhoe. Due to the possibility of excavating landfilled wastes, the forced air respirator system was set up for use if required. As well, the photo–ionizing volatile vapour detector was used to monitor the excavation for presence of volatile vapours. An open–topped dumpster was delivered to the site for use to dispose of any wastes present in the excavation spoil.

Since no wastes were encountered during the test pit excavation, as much spoil as possible was replaced in the test pits and compacted using the backhoe. The remaining soils were placed in the dumpster and removed the same day for landfill disposal.

A.2 SURFACE WATER INVESTIGATIONS

Field Measurements

Flow measurements were taken when possible using a PVM2A velocity meter. This meter is an electromagnetic meter designed to gauge under low flow conditions. Flow measurements were taken through a cross section of the stream with velocity measurements taken at discrete horizontal and vertical locations across the stream. Velocity measurements were recorded and flow rate calculated back at the office.

Conductivity measurements were taken using a portable electronic conductivity meter which was calibrated in the field to the ambient water temperature. Conductivity measurements were taken in the same location as water samples and measurements were recorded in field note book.

The pH measurements were taken using an electronic pH stick. This meter was calibrated on each monitoring day prior to its use. The pH readings were taken at the same locations as water samples and recorded in the field note book.

Dissolved oxygen concentrations were taken with a hach kit at all stations in May and June and at stations SW1 through SW5 in August. A YSI temperature dissolved oxygen meter was used for samples take in the Bay of Quinte in August 1990. The hach kit was used following the directions and concentrations were recorded in the filed note book. The YSI was air calibrated, based of elevation, prior to use and tested against a hach kit measurement.

Water Samples

Water Samples taken on site at stations SW1–5 were taken at mid stream locations. Sample bottles with out preservative were rinsed three times with ambient water. The volume of sample collected met laboratory requirements.

Water samples taken in Bay of Quinte were taken at surface in May and June, at stations SW6–9. These samples were taken using an extension device to collect a water sample just off shore and below the surface. In August water samples from the Bay of Quinte were collected from a boat which was loaned to Gartner Lee through the Belleville MOE office. Samples were again collected at the original stations (SW6–9) just below the surface. Samples from additional stations SW12–17, were taken at the sediment water interface using a Van Doran water bottle. Conductivity, and pH were also taken from the water collected with the Van Doran.

Water samples taken at SW11 at the mouth of the Moria River were collected using the Van Doran water bottle and were taken off the Highway 2 bridge.

Health and Safety

Rubber gloves were worn for all sample collection and all instruments and personal items were washed and clean prior to leaving the site. Gartner Lee health and safety boating protocols were followed for all work conducted from the boat in August 1990.

APPENDIX B

BOREHOLE LOGS AND MONITOR DETAILS

GRAPHICS, SYMBOLS AND ABBREVIATIONS ON LOGS

SAMPLE TYPES and TESTS

SS	Split Spoon Sample
SN	Non Standard Split Spoon Sample
ST	Shelby Tube Sample
DS	Denision Type Sample
PS	Piston Type Sample
CS	Continuous Sample
GS	Grab Sample
WS	Wash Sample
BQ	BQ Core Sample
HQ	HQ Core Sample
NQ	NQ Core Sample
DT	Dynamic Penetration Test
VT	Field Vane Test (undisturbed) - +
VT	Field Vane Test (remoulded) - ⊕

PENETRATION RESISTANCES

Dynamic Penetration Resistance

The number of blows by a 63.6 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60^{o} cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

Standard Penetration Resistance (N Value)

The number of blows by a 63.6 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split spoon sampler for a distance of 300 mm (12 in.).

ABBREVIATIONS

DTPL: Drier Than Plastic Limit
APL: About Plastic Limit
WTPL: Wetter Than Plasic Limit
K: Hydraulic Conductivity (m/s)
C_u: Shear Strength (kPa)

GRAIN SIZE CLASSIFICATION

	%
"trace", eg. trace sand	1 - 10
"some", eg. some sand	10 - 20
adjective, eg. sandy	20 - 35
"and", eg. and sand	35 - 50
noun, eg. sand	>50

Note: Classification Divisions Based on Modified M.I.T Grain Size Scale

SOIL DESCRIPTIONS

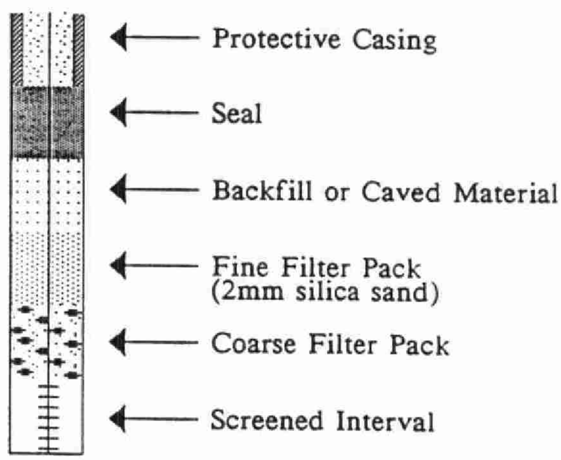
Cohesionless Soils

Relative Density	N Value
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	over 50

Cohesive Soils

Consistency	C_u(kPa)	N Value
Very soft	0 to 12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	over 200	over 30

MONITOR DETAILS



BOREHOLE LOG

PROJECT: 90-119

BOREHOLE: 1

Hydrogeological Assessment of Zwick's Island
Zwick's Island, Belleville
FOR: Ministry of the Environment

DATE: 5 April 1990
GEOLOGIST PW
ELEVATION 76.0 m ASL

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	SAMPLE NUMBER	TYPE	N VALUE	% WATER	% REC	% RQD	COMMENTS
	FILL Brown to dark grey silty clay to clayey silt with sand, gravel and boulders. Rootlets in upper 0.18 m. Moist. Very stiff.							Background TIP reading 6.8 to 13.5
1		1	SS	26 25mm				TIP reading in sample bag 4.0
		2	SS	23				TIP reading in sample bag 4.0
2								
2.7	**SAND** Grey medium to coarse sand with gravel. Saturated. Very dense							
3		3	SS	50 127mm				TIP reading in sample bag 3.7
4								
	Becoming fine grey sand below +/- 4.6 m. Saturated. Dense.	4	SS	31				TIP reading in sample bag 3.0
5.0 5	Borehole terminated at 5.0 m in fine sand.							

BOREHOLE LOG

BOREHOLE LOG	PROJECT: 90-119	BOREHOLE: 2
Hydrogeological Assessment of Zwick's Island Zwick's Island, Belleville FOR: Ministry of the Environment		DATE: 5 April 1990 GEOLOGIST PW ELEVATION 76.1 m ASL

DEPTH (m)	STRATIGRAPHY	STRATIGRAPHIC DESCRIPTION	MONITOR DETAILS & NUMBER	SAMPLE NUMBER	INTERVAL	TYPE	N VALUE	% WATER	% REC	% RQD	COMMENTS
0 – 1.4		**FILL** Brown silty clay with sand and gravel. Trace rootlets above 0.6 m. Moist. Stiff to hard.		1		SS	50 152mm				Background TIP reading 2.4 to 4.0
											TIP reading in sample bag 0.6
				2		SS	13				TIP reading in sample bag 1.4
1.4 – 3.4		**REFUSE** Brown to black silty sand with clay, gravel, boulders, brick, cloth, wood, plastic, paper and wire. Saturated.		3		SS					TIP reading in sample bag 1.6
				4		SS					TIP reading in sample bag 1.7
3.4 – 4.1		**BOULDERS AND SILTY SAND** Grey silty sand with clay and numerous boulders. Saturated.		5		SS					TIP reading in sample bag 2.0

Borehole terminated at 4.1 m at probable bedrock surface.

BOREHOLE LOG	PROJECT: 90-119	BOREHOLE: 3
Hydrogeological Assessment of Zwick's Island Zwick's Island, Belleville FOR: Ministry of the Environment		DATE: 5 April 1990 GEOLOGIST PW ELEVATION 76.7 m ASL

DEPTH (m)	STRATIGRAPHY	STRATIGRAPHIC DESCRIPTION	MONITOR DETAILS & NUMBER	SAMPLE NUMBER	INTERVAL	TYPE	N VALUE	% WATER	% REC	% RQD	COMMENTS
		FILL Brown silty clay with sand gravel and boulders. Moist. Occasional rootlets above +/- 1 m. Moist. Very stiff to hard.		1		SS	24				Background TIP reading 2.0 to 3.9
1				2		SS	40 127mm				TIP reading in sample bag 4.0 TIP reading in sample bag 4.2
2				3		SS	50 76mm				TIP reading in sample bag 4.2
3.1 3		**SAND WITH GRAVEL** Dark brown to grey fine to coarse sand with gravel. Saturated. Compact to very dense.		4		SS	18				TIP reading in sample bag 4.5
4											
4.9				5		SS	50 127mm				TIP reading in sample bag 4.1
		Borehole terminated at 4.9 m in sand with gravel.									

BOREHOLE LOG

BOREHOLE LOG	**PROJECT:** 90-119	**BOREHOLE:** 4

Hydrogeological Assessment of Zwick's Island
Zwick's Island, Belleville
FOR: Ministry of the Environment

DATE: 5 April 1990
GEOLOGIST PW
ELEVATION 76.6 m ASL

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	SAMPLE NUMBER	TYPE	N VALUE	% WATER	% REC	% RQD	COMMENTS
0.7	**FILL** Brown to grey silty clay with sand and gravel. Moist. Hard.	1	SS	47				Background TIP reading 3.8 to 3.9
								TIP reading in sample bag 4.2
3.1	**REFUSE** Mottled brown-black silty clay with sand, wood, paper, plastic, cloth and wire. Moist to saturated. Firm.	2	SS	8				TIP reading in sample bag 3.9
		3	SS	8				TIP reading in sample bag 3.9
4.6	**SAND WITH GRAVEL** Dark grey fine to coarse sand with gravel and boulders. Saturated. Very loose to very dense.	4	SS	2				TIP reading in sample bag 4.1
		5	SS	26				TIP reading in sample bag 4.2
		6	SS	50 51mm				TIP reading in sample bag 4.2
	Borehole terminated at 4.6 m in sand with gravel.							

BOREHOLE LOG

PROJECT: 90-119

BOREHOLE: 5

Hydrogeological Assessment of Zwick's Island
Zwick's Island, Belleville
FOR: Ministry of the Environment

DATE: 6 April 1990
GEOLOGIST PW
ELEVATION 76.6 m ASL

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	SAMPLE NUMBER	TYPE	N VALUE	% WATER	% REC	% RQD	COMMENTS
	FILL Brown fine to medium sand with silt. Occasional rootlets. Damp to moist. Very stiff.	1	SS	29				Background TIP reading 1.8
								TIP reading in sample bag 2.6
0.9		2	SS	17				TIP reading in sample bag 1.9
	REFUSE Dark brown to black silty sand to fine to medium sand with paper, wood, coal-like pieces, glass and brick. Saturated. Compact to dense.	3	SS	12				TIP reading in sample bag 7.1
		4	SS	37				TIP reading in sample bag 4.9
4.7		5	SS	50				TIP reading in sample bag 10.3
4.8	**SAND WITH GRAVEL** Grey medium to coarse sand with gravel. Saturated. Very dense.			76mm				

Borehole terminated at 4.8 m at probable bedrock surface.

BOREHOLE LOG

BOREHOLE LOG	PROJECT: 90-119	BOREHOLE: 6
Hydrogeological Assessment of Zwick's Island Zwick's Island, Belleville FOR: Ministry of the Environment		DATE: 6 April 1990 GEOLOGIST PW ELEVATION 76.8 m ASL

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	SAMPLE NUMBER	TYPE	N VALUE	% WATER	% REC	% RQD	COMMENTS
	FILL Brown silty clay to clayey silt with gravel, boulders and rootlets. Moist. Firm to very stiff.	1	SS	8				Background TIP reading 2.9
								TIP reading in sample bag 3.9
1		2	SS	25				TIP reading in sample bag 4.2
1.8		3	SS	50 152mm				TIP reading in sample bag 4.6
2	**REFUSE** Brown silty clay with trace sand and gravel, timber, brick and roots. Moist to saturated. Very stiff to hard.							
3		4	SS	28				TIP reading in sample bag 2.9
3.4	**SAND WITH GRAVEL** Grey medium to coarse sand with gravel and boulders. Saturated. Very dense.							
4		5	SS	50 102mm				TIP reading in sample bag 3.0
4.9		6	SS	50 152mm				TIP reading in sample bag 3.0
	Borehole terminated at 4.9 m in sand with gravel.							

BOREHOLE LOG	PROJECT: 90-119	BOREHOLE: 7
Hydrogeological Assessment of Zwick's Island Zwick's Island, Belleville FOR: Ministry of the Environment		DATE: 6 April 1990 GEOLOGIST PW ELEVATION 76.1 m ASL

DEPTH (m)	STRATIGRAPHY	STRATIGRAPHIC DESCRIPTION	MONITOR DETAILS & NUMBER	SAMPLE NUMBER	INTERVAL	TYPE	N VALUE	% WATER	% REC	% RQD	COMMENTS
		FILL Brown silty clay with gravel and roots. Moist. Soft to stiff. Becoming pink silty clay with gravel below +/- 0.5 m. Becoming black fiberous material below +/- 0.9 m. Becoming green silty clay with sand and gravel below +/- 1.5 m. Saturated.		1		SS	11				Background TIP reading 2.7
1				2		SS	3				TIP reading in sample bag 3.3 TIP reading in sample bag 4.4
				3		SS	28				TIP reading in sample bag 4.0
2.1 2		**REFUSE** Brown silty clay with plastic and rubber. Moist.									
3.1 3		**SILTY CLAY TILL** Light brown silty clay till. Damp to moist. Hard.		4		SS	43				TIP reading in sample bag 4.9
4 4.3											
		Borehole terminated at 4.3 m at probable bedrock surface.									

BOREHOLE LOG	PROJECT: 90-119	BOREHOLE: 8
Hydrogeological Assessment of Zwick's Island Zwick's Island, Belleville FOR: Ministry of the Environment		DATE: 6 April 1990 GEOLOGIST PW ELEVATION 76.3 m ASL

DEPTH (m)	STRATIGRAPHY	STRATIGRAPHIC DESCRIPTION	MONITOR DETAILS & NUMBER	SAMPLE NUMBER	INTERVAL	TYPE	N VALUE	% WATER	% REC	% RQD	COMMENTS
0.5		**FILL** Brown silty clay with sand, gravel and rootlets. Moist. Very stiff.		1		SS	18				Background TIP reading 1.9 to 2.6 TIP reading in sample bag 3.7
3.4		**REFUSE** Brown to black fine to medium sand with boulders, wood and brick. Saturated. Very stiff.		2		SS	17				TIP reading in sample bag 4.9
				3		SS	19				TIP reading in sample bag 3.1
4.6		**SAND WITH GRAVEL** Grey fine to coarse sand with trace silt, gravel and boulders. Saturated. Very dense.		4		SS	51				TIP reading in sample bag 3.0
4.7		**SILTY SAND TILL** Grey fine sand to silty sand till. Damp. Very dense.		5		SS	50 152mm				TIP reading in sample bag 2.7 to 3.2

Borehole terminated at 4.7 m in silty sand till.

BOREHOLE LOG

PROJECT: 90-119

BOREHOLE: 9

Hydrogeological Assessment of Zwick's Island
Zwick's Island, Belleville
FOR: Ministry of the Environment

DATE: 6 April 1990
GEOLOGIST PW
ELEVATION 76.2 m ASL

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	SAMPLE NUMBER	TYPE	N VALUE	% WATER	% REC	% RQD	COMMENTS
0 – 1.5	**FILL** Brown silty clay with roots and occasional gravel. Moist. Stiff to hard.	1	SS	47				Background TIP reading 2.1
		2	SS	12				TIP reading in sample bag 3.4 TIP reading in sample bag 3.2
1.5 – 3.8	**REFUSE** Brown silty clay with paper and rubber. Saturated. Very stiff.	3	SS	13 25mm				TIP reading in sample bag 3.0
	Becoming dark brown to black fibrous material below +/- 3 m.	4	SS	30				TIP reading in sample bag 1.3
3.8 – 4.3	**SAND** Brown medium to coarse sand. Saturated. Compact.	5	SS	14				TIP reading in sample bag 1.7

Borehole terminated at 4.3 m in sand.

TABLE B1: MONITOR DETAILS SUMMARY

Borehole		Monitor				Screened Interval (m.b.g.)	Filter Pack (m.b.g.)	Seal (m.b.g.)	Backfill (m.b.g.)
No.	Diameter (mm)	Type	Diameter (mm)	Stick–Up (m)	Top of Pipe Elevation (m.a.s.l.)				
1	178	S	51	0.67	76.65	3.66 – 0.61	3.66 – 0.50	0.50 – 0.00	5.03 – 3.66
2	178	S	51	0.42	76.56	3.97 – 0.92	3.97 – 0.85	0.85 – 0.24	4.11 – 0.97 0.24 – 0.00
3	127	S	51	0.49	77.15	3.70 – 0.65	3.70 – 0.60	0.60 – 0.00	4.88 – 3.70
4	127	S	51	0.50	77.04	3.77 – 0.72	3.77 – 0.60	0.60 – 0.00	4.62 – 3.77
5	178	S	51	0.33	76.96	4.45 – 1.40	4.45 – 0.60	0.60 – 0.00	4.80 – 4.45
6	178	S	51	0.55	77.32	3.64 – 0.59	3.64 – 0.50	0.50 – 0.00	4.88 – 3.64
7	178	S	51	0.56	76.60	4.16 – 1.11	4.16 – 0.91	0.91 – 0.30	4.27 – 4.16 0.30 – 0.00
8	178	S	51	0.53	76.85	3.97 – 0.92	3.97 – 0.61	0.61 – 0.00	4.72 – 3.97
9	178	S	51	0.38	76.53	3.57 – 0.52	3.57 – 0.45	0.45 – 0.00	4.27 – 3.57

m.a.s.l. – metres above sea level
m.b.g. – metres below ground

APPENDIX C

WATER LEVEL MONITORING RESULTS, COMBUSTIBLE GAS MONITORING RESULTS, AND SLUG TESTING RESULTS

TABLE C–1 : SUMMARY OF WATER LEVEL DATA

BOREHOLE NUMBER	GROUND ELEVATION (m.a.s.l.) (c)	TOP OF PIPE ELEVATION (m.a.s.l.)	APRIL 10/90		MAY 3/90		JUNE 8/90		AUGUST 29/90	
			WATER LEVEL (m.b.t.o.p.) (d)	WATER ELEVATION (m.a.s.l.)	WATER LEVEL (m.b.t.o.p.)	WATER ELEVATION (m.a.s.l.)	WATER LEVEL (m.b.t.o.p.)	WATER ELEVATION (m.a.s.l.)	WATER LEVEL (m.b.t.o.p.)	WATER ELEVATION (m.a.s.l.)
1	75.98	76.65	1.77	74.88	1.65	75.00	1.52	75.13	1.91	74.74
2	76.14	76.56	1.65	74.91	1.52	75.04	1.46	75.10	1.83	74.73
3	76.66	77.15	2.26	74.89	2.14	75.01	2.04	75.11	2.41	74.74
4	76.55	77.04	2.07	74.97	1.92	75.12	1.91	75.13	2.22	74.82
5	76.63	76.96	2.33	74.63	1.84	75.12	1.84	75.12	2.22	74.74
6	76.77	77.32	2.34	74.98	2.20	75.12	2.20	75.12	2.56	74.76
7	76.05	76.60	1.68	74.92	1.58	75.02	1.49	75.11	1.79	74.81
8	76.32	76.85	1.02	75.83	1.13	75.72	1.25	75.60	1.57	75.28
9	76.16	76.53	1.17	75.36	1.26	75.27	1.27	75.26	1.60	74.93
D1 (a)	75.78	–	0.87	74.91	0.80	74.98	ND	74.97 (f)	ND	74.59 (f)
D2 (b)	75.45	–	0.54	74.91	0.50	74.95	ND		ND	
				74.83 (e)		74.91 (e)				

<u>NOTES:</u>

(a) – D1 is a water level measuring point on a dock on the east side of Zwick's Island.
(b) – D2 is a water level measuring point on a dock on the west side of Zwick's Island.
(c) – m.a.s.l. : metres above sea level
(d) – m.b.t.o.p. : metres below top of pipe
(e) – Lake Ontario elevation as calculated from US Army Corps of Engineers data.
(f) – Lake Ontario elevations derived from US Army Corps of Engineers data. Only calculated data available since staff gauge inaccessible during monitoring trip.
ND – No data

TABLE C–2 : COMBUSTIBLE GAS MEASUREMENTS IN SHALLOW BOREHOLES

Shallow Borehole Number	Depth of Hole (m.b.g)	Combustible Gas Readings (% of LEL for Methane)	Comments
1	0.2	0	adjacent to pump house
2	0.9	0	adjacent to open pavillion
3	0.3	0	
4	0.3	0	adjacent to open amphitheatre
5	0.3	6	adjacent to storage sheds
6	0.6	0	
7	0.3	0	adjacent to railway tracks
8	0.9	3	immediately south of Ramada Inn
9	0.9	2	between Ramada Inn and tennis courts

Notes: All sampling locations shown on Figure Z.
m.b.g. – metres below ground
LEL – Lower Explosive Limit; for methane the LEL is approximately 5% methane by volume in air (eg. 100% LEL = 5% methane by volume in air)

SLUG TEST ANALYSIS

AFTER BOUWER & RICE, WATER RESOURCES RESEARCH, 1976

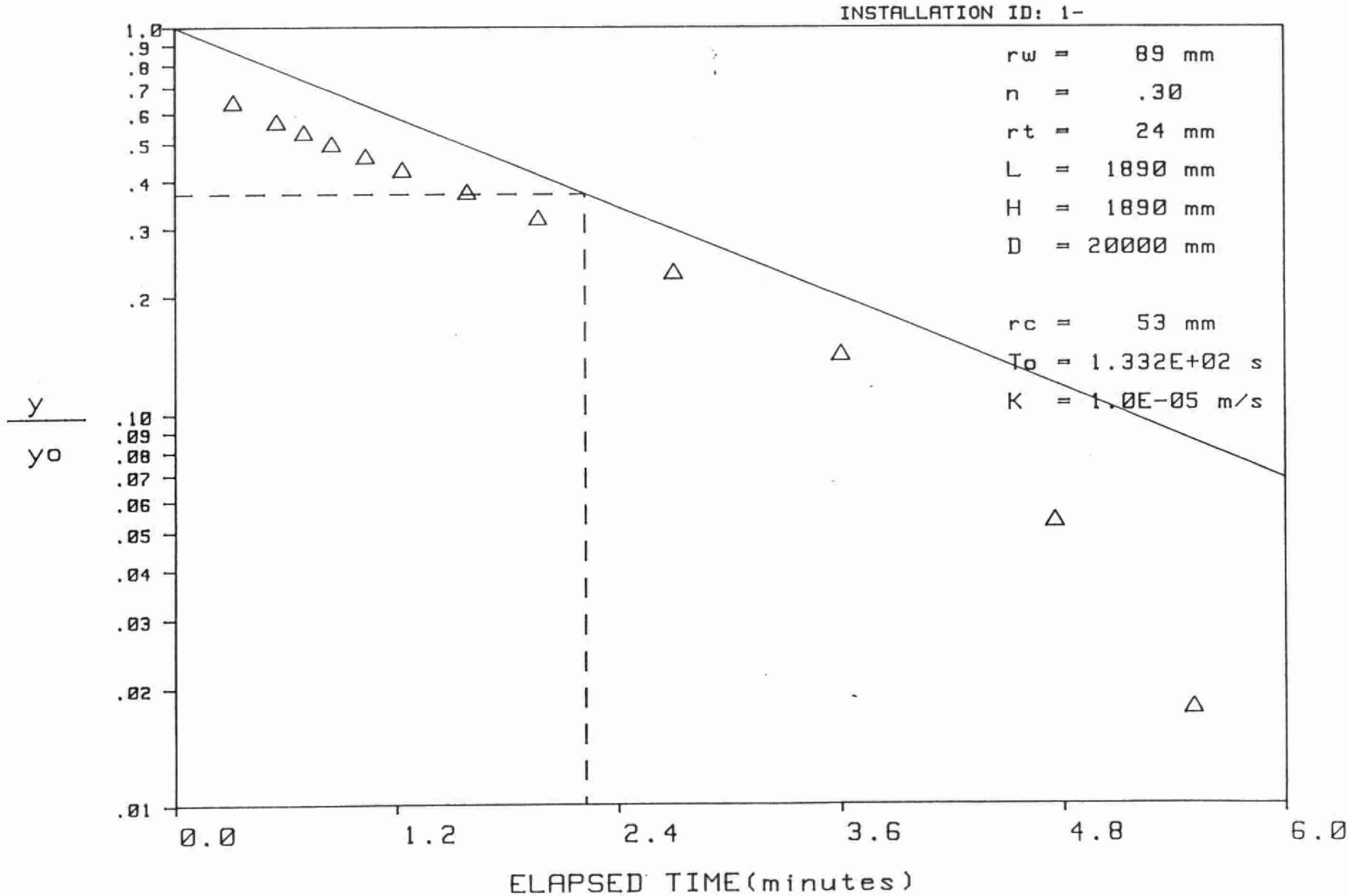
PROJECT NAME: CLOSED ZWICK'S ISLAND LANDFILL
PROJECT NUMBER: 90-119
INSTALLATION ID: 1-
TEST START DATE: 10 APR 1990
TEST START TIME: 09:00:00
STATIC WATER LEVEL (mbRP): 1.77
INITIAL WATER LEVEL (mbRP): 2.33

DATE	ACTUAL TIME	CUMULATIVE TIME (minutes)	WATER LEVEL (mbRP)	y / yo
10 APR 1990	09:00:19	.32	2.13	.64
10 APR 1990	09:00:33	.55	2.09	.57
10 APR 1990	09:00:42	.70	2.07	.54
10 APR 1990	09:00:51	.85	2.05	.50
10 APR 1990	09:01:02	1.03	2.03	.46
10 APR 1990	09:01:14	1.23	2.01	.43
10 APR 1990	09:01:35	1.58	1.98	.37
10 APR 1990	09:01:58	1.97	1.95	.32
10 APR 1990	09:02:42	2.70	1.90	.23
10 APR 1990	09:03:36	3.60	1.85	.14
10 APR 1990	09:04:45	4.75	1.80	.05
10 APR 1990	09:05:30	5.50	1.78	.02

NOTE - mbRP is metres below Reference Point elevation

SLUG TEST ANALYSIS

BOUWER AND RICE, WATER RESOURCES RESEARCH, 1976



PROJECT NAME: CLOSED ZWICK'S ISLAND LANDFILL PROJECT NUMBER: 90-119

SLUG TEST ANALYSIS

AFTER BOUWER & RICE, WATER RESOURCES RESEARCH, 1976

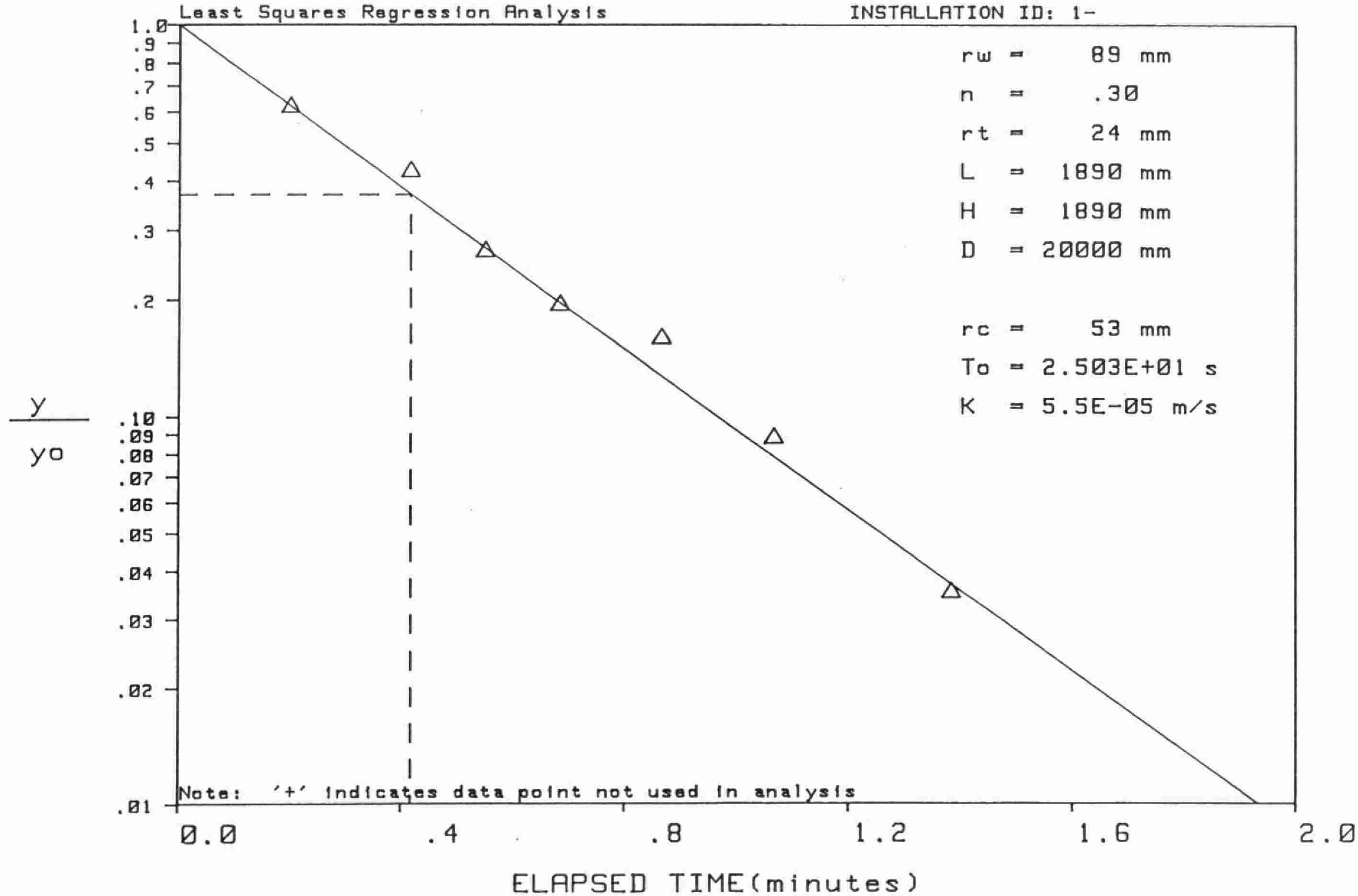
PROJECT NAME:	CLOSED ZWICK'S ISLAND LANDFILL
PROJECT NUMBER:	90-119
INSTALLATION ID:	1-
TEST START DATE:	10 APR 1990
TEST START TIME:	08:00:00
STATIC WATER LEVEL (mbRP):	1.77
INITIAL WATER LEVEL (mbRP):	1.21

DATE	ACTUAL TIME	CUMULATIVE TIME (minutes)	WATER LEVEL (mbRP)	$\frac{y}{yo}$
10 APR 1990	08:00:12	.20	1.42	.63
10 APR 1990	08:00:25	.42	1.53	.43
10 APR 1990	08:00:33	.55	1.62	.27
10 APR 1990	08:00:41	.68	1.66	.20
10 APR 1990	08:00:52	.87	1.68	.16
10 APR 1990	08:01:04	1.07	1.72	.09
10 APR 1990	08:01:23	1.38	1.75	.04

NOTE - mbRP is metres below Reference Point elevation

SLUG TEST ANALYSIS

BOUWER AND RICE, WATER RESOURCES RESEARCH, 1976



PROJECT NAME: CLOSED ZWICK'S ISLAND LANDFILL PROJECT NUMBER: 90-119

SLUG TEST ANALYSIS

AFTER BOUWER & RICE, WATER RESOURCES RESEARCH, 1976

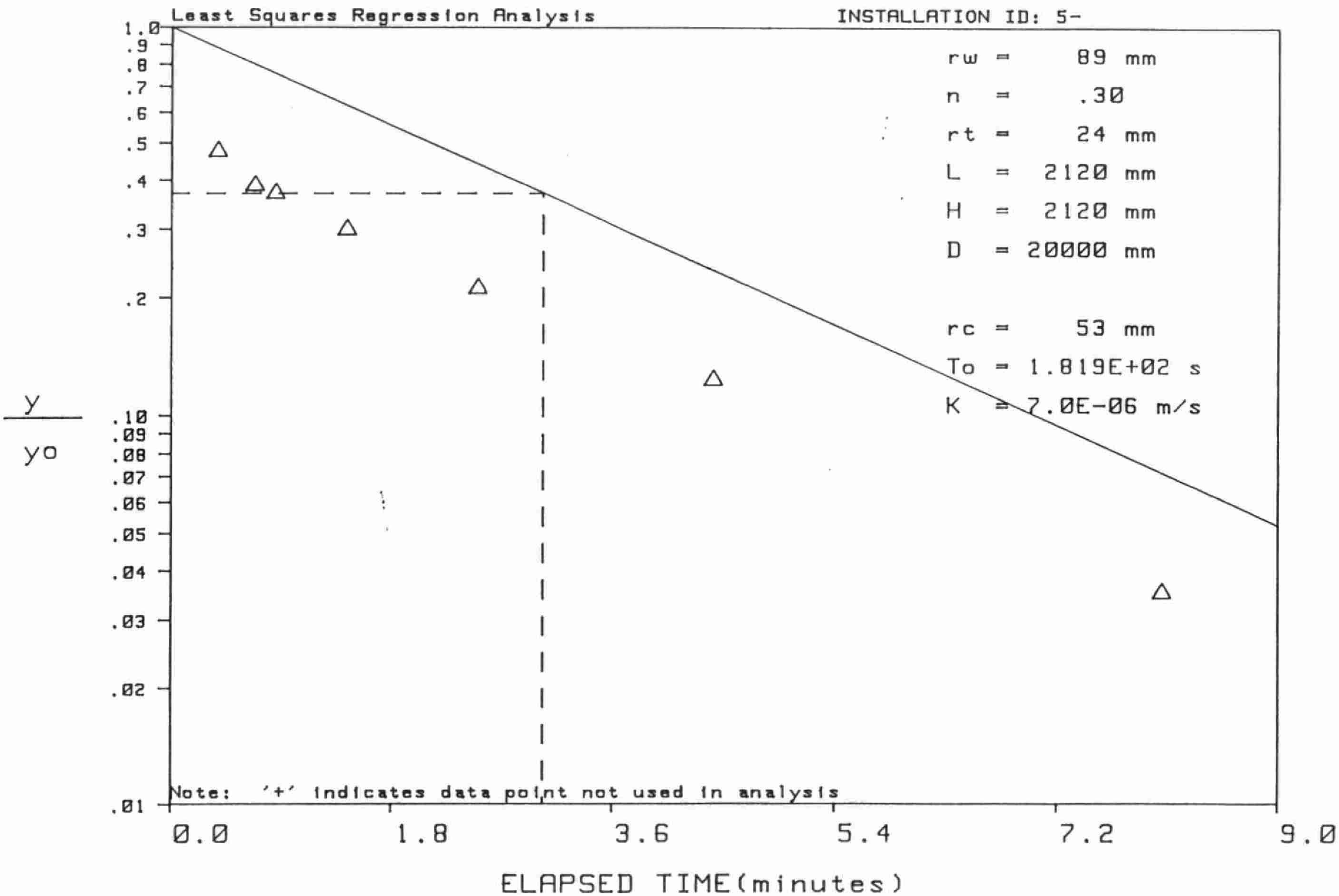
PROJECT NAME: CLOSED ZWICK'S ISLAND LANDFILL
PROJECT NUMBER: 90-119
INSTALLATION ID: 5-
TEST START DATE: 10 APR 1990
TEST START TIME: 10:00:00
STATIC WATER LEVEL (mbRP): 2.33
INITIAL WATER LEVEL (mbRP): 2.89

DATE	ACTUAL TIME	CUMULATIVE TIME (minutes)	WATER LEVEL (mbRP)	$\frac{y}{yo}$
10 APR 1990	10:00:23	.38	2.60	.48
10 APR 1990	10:00:41	.68	2.55	.39
10 APR 1990	10:00:51	.85	2.54	.37
10 APR 1990	10:01:26	1.43	2.50	.30
10 APR 1990	10:02:30	2.50	2.45	.21
10 APR 1990	10:04:25	4.42	2.40	.12
10 APR 1990	10:08:03	8.05	2.35	.04

NOTE - mbRP is metres below Reference Point elevation
- * data not used in regression analysis

SLUG TEST ANALYSIS

BOUWER AND RICE, WATER RESOURCES RESEARCH, 1976



PROJECT NAME: CLOSED ZWICK'S ISLAND LANDFILL PROJECT NUMBER: 90-119

SLUG TEST ANALYSIS

AFTER BOUWER & RICE, WATER RESOURCES RESEARCH, 1976

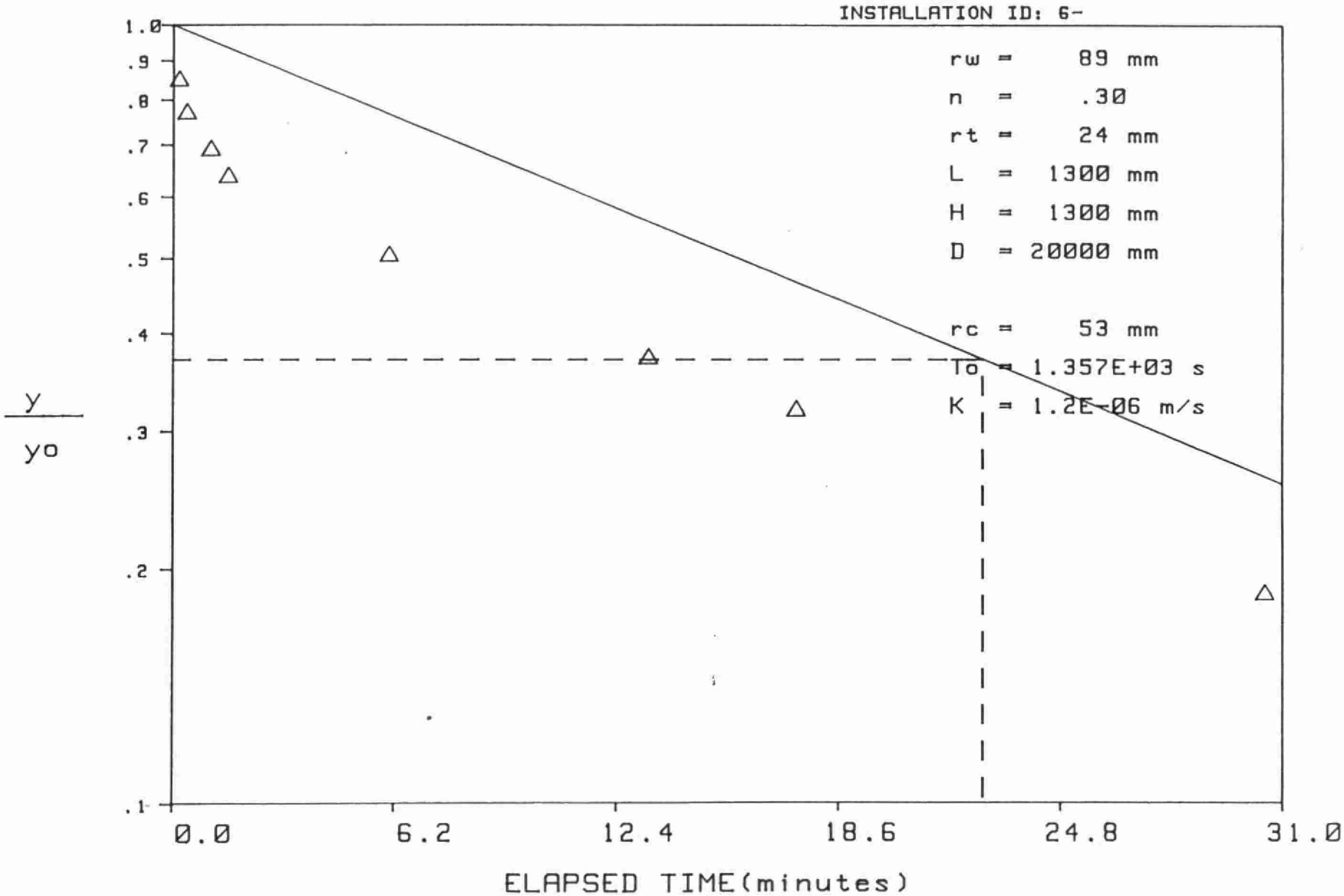
PROJECT NAME: CLOSED ZWICK'S ISLAND LANDFILL
PROJECT NUMBER: 90-119
INSTALLATION ID: 6-
TEST START DATE: 10 APR 1990
TEST START TIME: 11:00:00
STATIC WATER LEVEL (mbRP): 2.34
INITIAL WATER LEVEL (mbRP): 1.965

DATE	ACTUAL TIME	CUMULATIVE TIME (minutes)	WATER LEVEL (mbRP)	$\frac{y}{yo}$
10 APR 1990	11:00:11	.18	2.02	.85
10 APR 1990	11:00:24	.40	2.05	.77
10 APR 1990	11:01:04	1.07	2.08	.69
10 APR 1990	11:01:33	1.55	2.10	.64
10 APR 1990	11:06:03	6.05	2.15	.51
10 APR 1990	11:13:18	13.30	2.20	.37
10 APR 1990	11:17:25	17.42	2.22	.32
10 APR 1990	11:30:30	30.50	2.27	.19

NOTE - mbRP is metres below Reference Point elevation

SLUG TEST ANALYSIS

BOUWER AND RICE, WATER RESOURCES RESEARCH, 1976



PROJECT NAME: CLOSED ZWICK'S ISLAND LANDFILL PROJECT NUMBER: 90-119

SLUG TEST ANALYSIS

AFTER BOUWER & RICE, WATER RESOURCES RESEARCH, 1976

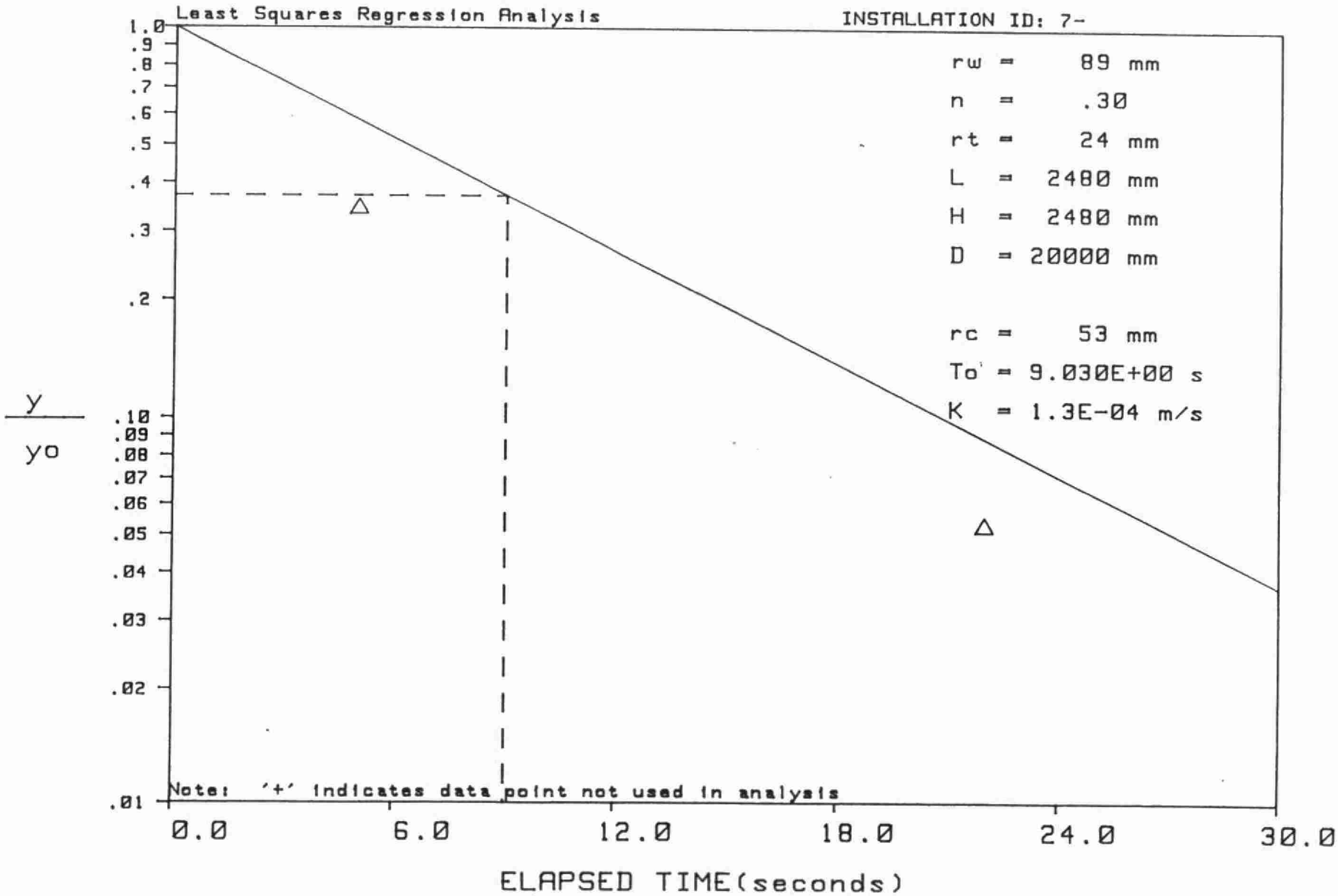
PROJECT NAME:	CLOSED ZWICK'S ISLAND LANDFILL
PROJECT NUMBER:	90-119
INSTALLATION ID:	7-
TEST START DATE:	10 APR 1990
TEST START TIME:	12:00:00
STATIC WATER LEVEL (mbRP):	1.68
INITIAL WATER LEVEL (mbRP):	1.305

DATE	ACTUAL TIME	CUMULATIVE TIME (seconds)	WATER LEVEL (mbRP)	$\frac{y}{yo}$
10 APR 1990	12:00:05	5	1.55	.35
10 APR 1990	12:00:22	22	1.66	.05

NOTE - mbRP is metres below Reference Point elevation
- * data not used in regression analysis

SLUG TEST ANALYSIS

BOUWER AND RICE, WATER RESOURCES RESEARCH, 1976



PROJECT NAME: CLOSED ZWICK'S ISLAND LANDFILL PROJECT NUMBER: 90-119

APPENDIX D

GROUND WATER QUALITY

RESULTS FROM MAY SAMPLING EVENT

25-May-90

Page: 1
Copy: 2 of 2
Set : 1

Authority: Mr. Mark Sungalia
Project : 90-119 Purchase order :

Job: 905227 Status: Final

Type	Sample	F- IC mg/L	Cl- IC mg/L	NO2-N IC mg/L	PO4-3 IC mg/L	Br- IC mg/L	NO3-N IC mg/L	SO4= IC mg/L
water	BH2-1	<0.10	59.5	<0.20	<1.00	0.32	0.19	73.6
	BH2-2	<0.10	22.3	<0.20	<1.00	0.15	<0.02	22.5
	BH2-3	<0.10	53.5	<0.20	<1.00	0.56	<0.02	89.7
	BH2-4	<0.10	202.	<0.20	<1.00	1.67	<0.02	9.79
	BH2-5	<0.10	25.0	<0.20	<1.00	0.27	<0.02	7.69
	BH2-6	<0.10	247.	<0.20	<1.00	0.27	<0.02	83.7
	BH2-7	<0.10	137.	<0.20	<1.00	0.13	<0.02	63.8
	BH2-8	<0.10	225.	<0.20	<1.00	2.89	<0.02	2.90
	BH2-9	<0.10	85.3	<0.20	<1.00	0.43	<0.02	4.30
	Blank	<0.10	<0.01	<0.02	<0.10	<0.05	<0.02	<0.05
	QC Standard (actual)	0.40	25.2	1.08	2.00	1.88	0.43	61.7
	QC Standard (expected)	0.40	25.0	1.00	2.00	2.00	0.44	60.0
	Repeat BH2-1	<0.10	62.4	<0.20	<1.00	0.32	0.19	74.9

Authority: Mr. Mark Sungalia
Project : 90-119 Purchase order :

Job: 905227 Status: Final

Type	Sample	TKN A. Col. mg/L	BOD DO Elec. mg/L	Phenols 4-AAP mg/L	TSS Grav. mg/L	Total P A. Col. mg/L	Ag ICAP mg/L	Al ICAP mg/L
water	BH2-1	12.0	11.0	<0.0005	10167	0.370	<0.005	<0.05
	BH2-2	22.0	19.0	0.0060	2075	0.250	<0.005	<0.05
	BH2-3	15.0	17.8	<0.0005	5037	0.070	<0.005	<0.05
	BH2-4	108.	20.0	0.0300	20570	0.090	<0.005	<0.05
	BH2-5	37.0	19.5	0.0105	25279	0.090	<0.005	<0.05
	BH2-6	100.	26.0	<0.0005	32840	0.050	<0.005	<0.05
	BH2-7	9.20	11.0	<0.0005	69436	0.020	<0.005	<0.05
	BH2-8	26.0	13.0	0.0025	3081	0.070	<0.005	<0.05
	BH2-9	53.0	14.0	0.0015	5236	0.080	<0.005	<0.05
	Blank	<0.02	<0.5	<0.0005	<1	<0.002	<0.005	<0.05
	QC Standard (actual)	1.44	4.1	0.0100	95	0.085	<0.005	0.91
	QC Standard (expected)	1.40	4.1	0.0100	100	0.084	<0.005	1.00
	Repeat BH2-1	12.0	N	<0.0005	10730	0.290	<0.005	<0.05

Authority: Mr. Mark Sungalia
Project : 90-119 Purchase order :

Job: 905227 Status: Final

Type	Sample	B ICAP mg/L	Ba ICAP mg/L	Be ICAP mg/L	Ca ICAP mg/L	Cd ICAP mg/L	Co ICAP mg/L	Cr ICAP mg/L
water	BH2-1	0.172	0.562	<0.0005	189.	<0.005	<0.05	<0.01
	BH2-2	0.185	0.357	<0.0005	146.	<0.005	<0.05	<0.01
	BH2-3	0.211	0.273	<0.0005	199.	<0.005	<0.05	<0.01
	BH2-4	0.505	0.253	<0.0005	124.	<0.005	<0.05	<0.01
	BH2-5	0.214	0.293	<0.0005	164.	<0.005	<0.05	<0.01
	BH2-6	0.124	0.330	<0.0005	205.	<0.005	<0.05	<0.01
	BH2-7	0.178	0.480	<0.0005	162.	<0.005	<0.05	<0.01
	BH2-8	0.269	0.411	<0.0005	162.	<0.005	<0.05	<0.01
	BH2-9	0.215	0.571	<0.0005	119.	<0.005	<0.05	<0.01
	Blank	<0.005	<0.005	<0.0005	0.20	<0.005	<0.05	<0.01
	QC Standard (actual)	0.177	0.499	0.0187	9.54	0.198	0.19	0.19
	QC Standard (expected)	0.200	0.500	0.0200	10.0	0.200	0.20	0.20
	Repeat BH2-1	0.163	0.574	<0.0005	186.	<0.005	<0.05	<0.01

Authority: Mr. Mark Sungalia
Project : 90-119 Purchase order :

Job: 905227 Status: Final

Type	Sample	Cu ICAP mg/L	Fe ICAP mg/L	K ICAP mg/L	Mg ICAP mg/L	Mn ICAP mg/L	Mo ICAP mg/L	Na ICAP mg/L
water	BH2-1	<0.01	19.4	13.4	17.8	0.80	<0.2	44.2
	BH2-2	<0.01	43.7	10.0	14.7	0.41	<0.2	21.3
	BH2-3	<0.01	9.55	20.6	25.3	1.23	<0.2	70.8
	BH2-4	<0.01	41.6	59.4	31.1	0.49	<0.2	148.
	BH2-5	<0.01	39.4	18.1	14.7	0.79	<0.2	21.5
	BH2-6	<0.01	26.6	19.1	17.7	1.34	<0.2	141.
	BH2-7	<0.01	18.3	19.4	21.1	0.79	<0.2	59.5
	BH2-8	<0.01	42.2	15.8	23.1	0.30	<0.2	121.
	BH2-9	<0.01	41.0	10.6	15.5	0.22	<0.2	44.3
	Blank	<0.01	0.04	<0.5	0.02	<0.01	<0.2	<0.5
	QC Standard (actual)	0.19	0.82	10.0	9.83	0.18	<0.2	9.6
	QC Standard (expected)	0.20	1.00	10.0	10.0	0.20	<0.2	10.0
	Repeat BH2-1	<0.01	19.0	13.0	17.7	0.77	<0.2	44.4

Authority: Mr. Mark Sungalia
Project : 90-119 Purchase order :

Job: 905227 Status: Final

Type	Sample	Ni ICAP mg/L	P ICAP mg/L	Pb ICAP mg/L	Si ICAP mg/L	Sr ICAP mg/L	Th ICAP mg/L	Ti ICAP mg/L
water	BH2-1	<0.05	0.7	<0.05	7.42	1.05	<0.05	<0.005
	BH2-2	<0.05	0.9	<0.05	7.49	0.906	<0.05	<0.005
	BH2-3	<0.05	0.9	<0.05	6.83	1.32	<0.05	<0.005
	BH2-4	<0.05	1.0	<0.05	8.67	1.07	<0.05	<0.005
	BH2-5	<0.05	1.3	<0.05	9.03	1.05	<0.05	<0.005
	BH2-6	<0.05	1.2	<0.05	6.30	1.03	<0.05	<0.005
	BH2-7	<0.05	0.8	<0.05	6.76	1.04	<0.05	<0.005
	BH2-8	<0.05	1.0	<0.05	8.37	1.56	<0.05	<0.005
	BH2-9	<0.05	1.0	<0.05	8.34	0.725	<0.05	<0.005
	Blank	<0.05	<0.5	<0.05	<0.05	<0.005	<0.05	<0.005
	QC Standard (actual)	0.21	1.0	0.20	0.13	0.198	0.88	0.197
	QC Standard (expected)	0.20	1.0	0.20	<0.05	0.200	1.00	0.200
	Repeat BH2-1	<0.05	0.7	<0.05	7.26	1.07	<0.05	<0.005

Authority: Mr. Mark Sungalia
Project : 90-119 Purchase order :

Job: 905227 Status: Final

Type	Sample	V ICAP mg/L	Zn ICAP mg/L	Zr ICAP mg/L
water	BH2-1	<0.005	0.06	<0.02
	BH2-2	<0.005	0.06	<0.02
	BH2-3	<0.005	0.06	<0.02
	BH2-4	<0.005	0.06	<0.02
	BH2-5	<0.005	0.06	<0.02
	BH2-6	<0.005	0.06	<0.02
	BH2-7	<0.005	0.06	<0.02
	BH2-8	<0.005	0.05	<0.02
	BH2-9	<0.005	0.05	<0.02
	Blank	<0.005	<0.01	<0.02
	QC Standard (actual)	0.192	0.20	<0.02
	QC Standard (expected)	0.200	0.20	<0.02
	Repeat BH2-1	<0.005	0.06	<0.02

Authority: Mr. Mark Sungalia
Project : 90-119 Purchase order :

Job: 905227 Status: Final

Abbreviations:

Analyses:

F-	:	Fluoride ion concentration
Cl-	:	Chloride ion concentration
NO2-N	:	Nitrite ion concentration expressed as nitrogen
PO4-3	:	Phosphate ion concentration
Br-	:	Bromide ion concentration
NO3-N	:	Nitrate ion concentration expressed as nitrogen
SO4=	:	Total Sulphate ion concentration
TKN	:	Total Kjeldahl Nitrogen (Tot. N minus NO2-N & NO3-N)
BOD	:	Biochemical Oxygen Demand
Phenols	:	Phenolic compounds determined using the 4-AAP method
TSS	:	Total Suspended Solids
Total P	:	Total Phosphorus concentration
Ag	:	Silver concentration
Al	:	Aluminum concentration
B	:	Boron concentration
Ba	:	Barium concentration
Be	:	Beryllium concentration
Ca	:	Calcium concentration
Cd	:	Cadmium concentration
Co	:	Cobalt concentration
Cr	:	Chromium concentration

Authority: Mr. Mark Sungalia
Project : 90-119 Purchase order :

Job: 905227 Status: Final

Cu	:	Copper concentration
Fe	:	Total Iron Concentration
K	:	Potassium concentration
Mg	:	Magnesium concentration
Mn	:	Manganese concentration
Mo	:	Molybdenum concentration
Na	:	Sodium concentration
Ni	:	Nickel concentration
P	:	Phosphorus concentration
Pb	:	Lead concentration
Si	:	Silicon concentration
Sr	:	Strontium concentration
Th	:	Thorium concentration
Ti	:	Titanium concentration
V	:	Vanadium concentration
Zn	:	Zinc concentration
Zr	:	Zirconium concentration

Methods:

IC	:	Ion Chromatography
A. Col.	:	Automated Colourimetry
DO Elec.	:	Dissolved Oxygen Electrode
4-AAP	:	Colourimetry using 4-AAP method
Grav.	:	Gravimetric determination by weight
ICAP	:	Inductively-Coupled Argon Plasma Spectroscopy

Authority: Mr. Mark Sungalia
Project : 90-119 Purchase order :

Job: 905227 Status: Final

Units:

mg/L : Milligrams per Liter

Quality control:

< : Result obtained was below the detection limit
N : Not Applicable

Signed:
....
Agnes Love, B.Sc.
Supervisor, Environmental Inorganic Services

VOLATILE ORGANICS RESULTS (EPA 624) DATE: 28-May-90

PROJECT REF #90-119
W.O. # 90-5227V
MATRIX:WATER

ND = NOT DETECTED DF = DILUTION FACTOR
* = DETECTED AT A LEVEL BELOW STATED M.D.L.

	COMPOUND	M.D.L. UG/L	REAGENT BLANK	TRAVEL BLANK	BH2-1	BH2-1 REPEAT	BH2-2	BH2-3	BH2-4 DF=5
1	CHLOROMETHANE	2.0	ND	ND	ND	ND	ND	ND	ND
2	VINYL CHLORIDE	2.0	ND	ND	ND	ND	4.8	ND	ND
3	BROMOMETHANE	2.0	ND	ND	ND	ND	ND	ND	ND
4	CHLOROETHANE	5.0	ND	ND	ND	ND	ND	ND	ND
5	TRICHLOROFLUOROMETHANE	1.0	ND	ND	ND	ND	ND	ND	ND
6	1,1-DICHLOROETHENE	0.5	ND	ND	ND	ND	ND	ND	ND
7	DICHLOROMETHANE	2.0	ND	ND	ND	ND	ND	ND	ND
8	TRANS-1,2-DICHLOROETHENE	0.2	ND	ND	ND	ND	0.4	ND	ND
9	1,1-DICHLOROETHANE	0.2	ND	ND	ND	ND	ND	ND	ND
10	CHLOROFORM	0.2	ND	ND	ND	ND	0.3	ND	ND
11	1,1,1-TRICHLOROETHANE	0.2	ND	ND	ND	0.3	*0.1	ND	ND
12	CARBON TETRACHLORIDE	0.2	ND	ND	ND	ND	ND	ND	ND
13	BENZENE	0.1	ND	ND	1.3	1.7	5.4	0.3	9.7
14	1,2-DICHLOROETHANE	0.2	ND	ND	ND	ND	ND	ND	ND
15	TRICHLOROETHENE	0.2	ND	ND	ND	ND	1.1	ND	ND
16	1,2-DICHLOROPROPANE	0.2	ND	ND	ND	ND	ND	ND	ND
17	BROMODICHLOROMETHANE	0.2	ND	ND	ND	ND	ND	ND	ND
18	CIS-1,3-DICHLOROPROPENE	0.5	ND	ND	ND	ND	ND	ND	ND
19	TOLUENE	0.2	ND	ND	0.2	0.2	3.3	0.6	*0.8
20	TRANS-1,3-DICHLOROPROPENE	0.5	ND	ND	ND	ND	ND	ND	ND
21	1,1,2-TRICHLOROETHANE	0.5	ND	ND	ND	ND	ND	ND	ND
22	TETRACHLOROETHENE	0.5	ND	ND	ND	ND	1.4	ND	ND
23	DIBROMOCHLOROMETHANE	1.0	ND	ND	ND	ND	ND	ND	ND
24	CHLOROBENZENE	0.2	ND	ND	1.6	2.0	18.0	0.4	19.6
25	ETHYLBENZENE	0.2	ND	ND	ND	ND	0.6	ND	1.6
26	M-XYLENE & P-XYLENE	0.2	ND	ND	0.5	0.6	3.8	ND	18.8
27	O-XYLENE	0.2	ND	ND	0.2	0.2	1.3	ND	1.5
28	BROMOFORM	2.0	ND	ND	ND	ND	ND	ND	ND
29	1,1,2,2-TETRACHLOROETHANE	1.0	ND	ND	ND	ND	ND	ND	ND
30	1,3-DICHLOROBENZENE	0.2	ND	ND	ND	ND	ND	ND	ND
31	1,4-DICHLOROBENZENE	0.2	ND	ND	0.7	0.7	7.1	0.2	8.7
32	1,2-DICHLOROBENZENE	0.2	ND	ND	ND	ND	0.7	ND	*0.7
SURROGATE STANDARD RECOVERIES:		AMOUNT							
33	FLUOROBENZENE	4 UG/L	104%	144%	91%	87%	82%	80%	133%
34	4-BROMOFLUOROBENZENE	3 UG/L	97%	98%	108%	109%	115%	98%	102%

VOLATILE ORGANICS RESULTS (EPA 624) DATE: 28-May-90

W.O. # 90-5227V
MATRIX:WATER

ND = NOT DETECTED DF = DILUTION FACTOR
* = DETECTED AT A LEVEL BELOW STATED M.D.L.

	COMPOUND	M.D.L. UG/L	BH2-5 DF=5	BH2-6 DF=5	BH2-7 DF=5	BH2-8 DF=5	BH2-9 DF=5
1	CHLOROMETHANE	2.0	ND	ND	ND	ND	ND
2	VINYL CHLORIDE	2.0	ND	ND	ND	ND	ND
3	BROMOMETHANE	2.0	ND	ND	ND	ND	ND
4	CHLOROETHANE	5.0	ND	ND	ND	ND	ND
5	TRICHLOROFLUOROMETHANE	1.0	ND	ND	ND	ND	ND
6	1,1-DICHLOROETHENE	0.5	ND	ND	ND	ND	ND
7	DICHLOROMETHANE	1.0	ND	ND	ND	ND	ND
8	TRANS-1,2-DICHLOROETHENE	0.2	ND	ND	ND	ND	ND
9	1,1-DICHLOROETHANE	0.2	*0.6	ND	ND	ND	ND
10	CHLOROFORM	0.2	ND	ND	ND	ND	ND
11	1,1,1-TRICHLOROETHANE	0.2	ND	ND	ND	ND	ND
12	CARBON TETRACHLORIDE	0.2	ND	ND	ND	ND	ND
13	BENZENE	0.1	3.8	ND	ND	5.1	3.8
14	1,2-DICHLOROETHANE	0.2	ND	ND	ND	ND	ND
15	TRICHLOROETHENE	0.2	ND	ND	ND	ND	ND
16	1,2-DICHLOROPROPANE	0.2	ND	ND	ND	ND	ND
17	BROMODICHLOROMETHANE	0.2	ND	ND	ND	ND	ND
18	CIS-1,3-DICHLOROPROPENE	0.5	ND	ND	ND	ND	ND
19	TOLUENE	0.2	1.8	ND	ND	*0.7	*0.7
20	TRANS-1,3-DICHLOROPROPENE	0.5	ND	ND	ND	ND	ND
21	1,1,2-TRICHLOROETHANE	0.5	ND	ND	ND	ND	ND
22	TETRACHLOROETHENE	0.5	ND	ND	ND	ND	ND
23	DIBROMOCHLOROMETHANE	1.0	ND	ND	ND	ND	ND
24	CHLOROBENZENE	0.2	4.1	*0.6	ND	14.5	8.2
25	ETHYLBENZENE	0.2	4.5	ND	ND	ND	ND
26	M-XYLENE & P-XYLENE	0.2	54.4	ND	ND	3.1	0.8
27	O-XYLENE	0.2	5.5	ND	ND	1.6	1.3
28	BROMOFORM	2.0	ND	ND	ND	ND	ND
29	1,1,2,2-TETRACHLOROETHANE	1.0	ND	ND	ND	ND	ND
30	1,3-DICHLOROBENZENE	0.2	ND	ND	ND	ND	ND
31	1,4-DICHLOROBENZENE	0.2	3.6	ND	ND	5.5	2.4
32	1,2-DICHLOROBENZENE	0.2	ND	ND	ND	*0.9	*0.6
	SURROGATE STANDARD RECOVERIES:	AMOUNT					
33	FLUOROBENZENE	4 UG/L	92%	112%	90%	120%	104%
34	4-BROMOFLUOROBENZENE	3 UG/L	128%	101%	113%	137%	125%

QUALITY CONTROL SPIKE PERCENT RECOVERIES DATE: 28-May-90

PROJECT REF #90-119
W.O. # 90-5227V
MATRIX:WATER

	COMPOUND	AMOUNT UG/L	REAGENT SPIKE
1	CHLOROMETHANE	10.0	124%
2	VINYL CHLORIDE	10.0	128%
3	BROMOMETHANE	10.0	124%
4	CHLOROETHANE	10.0	131%
5	TRICHLOROFLUOROMETHANE	5.0	119%
6	1,1-DICHLOROETHENE	5.0	130%
7	DICHLOROMETHANE	5.0	92%
8	TRANS-1,2-DICHLOROETHENE	5.0	128%
9	1,1-DICHLOROETHANE	5.0	114%
10	CHLOROFORM	5.0	178%
11	1,1,1-TRICHLOROETHANE	5.0	117%
12	CARBON TETRACHLORIDE	5.0	125%
13	BENZENE	5.0	153%
14	1,2-DICHLOROETHANE	5.0	87%
15	TRICHLOROETHENE	5.0	188%
16	1,2-DICHLOROPROPANE	5.0	65%
17	BROMODICHLOROMETHANE	5.0	117%
18	CIS-1,3-DICHLOROPROPENE	7.5	102%
19	TOLUENE	5.0	103%
20	TRANS-1,3-DICHLOROPROPENE	2.5	99%
21	1,1,2-TRICHLOROETHANE	5.0	102%
22	TETRACHLOROETHENE	5.0	107%
23	DIBROMOCHLOROMETHANE	5.0	98%
24	CHLOROBENZENE	5.0	101%
25	ETHYLBENZENE	5.0	104%
26	M-XYLENE & P-XYLENE	1.6	102%
27	O-XYLENE	1.6	101%
28	BROMOFORM	5.0	102%
29	1,1,2,2-TETRACHLOROETHANE	5.0	99%
30	1,3-DICHLOROBENZENE	3.1	104%
31	1,4-DICHLOROBENZENE	2.7	104%
32	1,2-DICHLOROBENZENE	3.2	104%

SURROGATE STANDARD RECOVERIES:

	COMPOUND	AMOUNT UG/L	REAGENT SPIKE
33	FLUOROBENZENE	3.6	102%
34	4-BROMOFLUOROBENZENE	3.0	102%

RESULTS FROM JUNE SAMPLING EVENT

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905655 Status: Final

Type	Sample	pH pH Elec. pH Units	Tot. Alk. Titr. 1 mg CaCO3/L	Sp. Cond. SS Elec. umhos/cm	F- IC mg/L	Cl- IC mg/L	NO2-N A. Col. mg/L	PO4-3 IC mg/L
water	BH-1	7.03	401	798	0.16	14.0	0.01	<1.0
	BH-2	6.78	670	1202	0.11	23.3	0.01	<1.0
	BH-3	7.00	960	1850	0.19	78.2	0.01	<1.0
	BH-4	7.33	1230	2630	0.15	200.	0.03	<1.0
	BH-5	7.03	886	1570	0.14	39.7	0.02	<1.0
	BH-6	7.05	777	2330	0.13	362.	0.02	<1.0
	BH-7	7.10	505	1430	0.15	180.	0.00	<1.0
	BH-8	7.04	722	1870	0.12	237.	0.01	<1.0
	BH-9	7.10	597	1350	0.10	98.5	0.02	<1.0
	BH-10	6.96	673	1215	0.11	24.5	0.02	<1.0
	TRIP BLANK	5.72	2	3	<0.10	<0.01	<0.00	<0.1
	Blank	5.44	1	1	<0.10	<0.01	<0.00	<0.1
	QC Standard (actual)	4.45	247	716	0.58	25.0	0.01	2.0
	QC Standard (expected)	4.45	250	718	0.60	25.0	0.01	2.0
	Repeat BH-1	7.01	402	799	0.14	14.4	0.01	1.0

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905655 Status: Final

Type	Sample	Br- IC mg/L	NO3-N IC mg/L	SO4= IC mg/L	TKN A. Col. mg/L	NH3-N A. Col. mg/L	Total P A. Col. mg/L	BOD DO Elec. mg/L
water	BH-1	<0.50	<0.20	47.9	11.0	5.60	0.030	4.8
	BH-2	<0.50	<0.20	15.1	38.0	30.0	0.030	21.0
	BH-3	<0.50	<0.20	71.9	26.0	23.0	0.030	8.8
	BH-4	1.20	<0.20	4.70	100.	93.0	0.005	19.0
	BH-5	<0.50	<0.20	<0.50	40.0	25.0	0.005	31.0
	BH-6	<0.50	<0.20	19.2	24.0	23.0	0.030	12.5
	BH-7	<0.50	<0.20	59.6	4.80	3.80	0.050	3.8
	BH-8	2.20	<0.20	<0.50	38.0	14.0	0.050	12.0
	BH-9	<0.50	<0.20	<0.50	52.0	34.0	0.050	11.0
	BH-10	<0.50	<0.20	15.0	44.0	21.0	0.220	3.7
	TRIP BLANK	<0.05	<0.02	<0.05	<0.02	0.06	0.005	0.3
	Blank	<0.05	<0.02	<0.05	<0.02	<0.02	<0.002	0.3
	QC Standard (actual)	1.91	0.44	61.0	1.33	1.53	0.139	6.2
	QC Standard (expected)	2.00	0.44	60.0	1.40	1.50	0.140	6.0
	Repeat BH-1	<0.50	<0.20	47.6	10.0	5.90	0.030	4.8

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905655 Status: Final

Type	Sample	TDS Grav. mg/L	TSS Grav. mg/L	DOC A. Col. mg/L	Phenols 4-AAP mg/L	C-Hard. Calc. mg CaCO3/L	Ag ICAP mg/L	Al ICAP mg/L
water	BH-1	544	22600.0	7.5	<0.0005	367.4	<0.005	<0.05
	BH-2	700	4555.00	9.3	0.0075	364.0	<0.005	<0.05
	BH-3	1228	620.00	15.0	0.0045	582.5	<0.005	<0.05
	BH-4	1414	3136.00	33.0	0.0195	392.8	<0.005	<0.05
	BH-5	912	5369.00	15.0	0.0095	460.5	<0.005	<0.05
	BH-6	1324	7273.00	12.0	0.0050	470.4	<0.005	<0.05
	BH-7	908	40224.0	7.4	0.0020	473.8	<0.005	<0.05
	BH-8	1042	7438.00	12.0	0.0040	456.1	<0.005	<0.05
	BH-9	650	838.00	10.0	0.0025	322.3	<0.005	<0.05
	BH-10	686	4961.00	10.0	0.0075	376.1	<0.005	<0.05
	TRIP BLANK	7	<0.10	0.3	<0.0005	<0.2	<0.005	<0.05
	Blank	8	<0.10	<0.2	<0.0005	0.3	<0.005	<0.05
	QC Standard (actual)	762	44.20	9.9	0.0100	62.4	<0.005	0.93
	QC Standard (expected)	750	50.00	10.0	0.0100	66.2	<0.005	1.00
	Repeat BH-1	544	22800.0	7.5	<0.0005	364.5	<0.005	<0.05

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905655 Status: Final

Type	Sample	B ICAP mg/L	Ba ICAP mg/L	Be ICAP mg/L	Ca ICAP mg/L	Cd ICAP mg/L	Co ICAP mg/L	Cr ICAP mg/L
water	BH-1	0.095	0.222	<0.0005	129.	<0.005	<0.05	<0.01
	BH-2	0.157	0.363	<0.0005	126.	<0.005	<0.05	<0.01
	BH-3	0.253	0.302	<0.0005	191.	<0.005	<0.05	<0.01
	BH-4	0.458	0.264	<0.0005	111.	<0.005	<0.05	<0.01
	BH-5	0.300	0.475	<0.0005	158.	<0.005	<0.05	<0.01
	BH-6	0.123	0.385	<0.0005	161.	<0.005	<0.05	<0.01
	BH-7	0.178	0.388	<0.0005	164.	<0.005	<0.05	<0.01
	BH-8	0.262	0.411	<0.0005	148.	<0.005	<0.05	<0.01
	BH-9	0.214	0.640	<0.0005	108.	<0.005	<0.05	<0.01
	BH-10	0.147	0.375	<0.0005	130.	<0.005	<0.05	<0.01
	TRIP BLANK	<0.005	<0.005	<0.0005	<0.05	0.006	<0.05	<0.01
	Blank	<0.005	<0.005	<0.0005	0.10	0.006	<0.05	<0.01
	QC Standard (actual)	0.180	0.510	0.0191	9.54	0.202	0.18	0.18
	QC Standard (expected)	0.200	0.500	0.0200	10.0	0.200	0.20	0.20
	Repeat BH-1	0.098	0.224	<0.0005	128.	<0.005	<0.05	<0.01

29-Jun-90

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905655 Status: Final

Type	Sample	Cu ICAP mg/L	Fe ICAP mg/L	K ICAP mg/L	Mg ICAP mg/L	Mn ICAP mg/L	Mo ICAP mg/L	Na ICAP mg/L
water	BH-1	<0.01	9.78	5.4	10.9	0.48	<0.2	15.1
	BH-2	<0.01	41.3	7.5	11.9	0.39	<0.2	17.3
	BH-3	<0.01	17.5	23.9	25.5	1.20	<0.2	75.3
	BH-4	<0.01	41.6	53.9	28.0	0.36	<0.2	146.
	BH-5	<0.01	47.6	18.7	15.9	0.77	<0.2	35.4
	BH-6	<0.01	30.3	16.9	16.5	0.88	<0.2	220.
	BH-7	<0.01	17.7	15.8	15.5	0.94	<0.2	89.2
	BH-8	<0.01	39.2	13.4	20.9	0.28	<0.2	116.
	BH-9	<0.01	38.3	8.9	12.7	0.18	<0.2	44.8
	BH-10	<0.01	41.6	7.8	12.4	0.40	<0.2	17.9
	TRIP BLANK	<0.01	0.04	<0.5	<0.01	<0.01	<0.2	<0.5
	Blank	<0.01	0.06	<0.5	0.01	<0.01	<0.2	<0.5
	QC Standard (actual)	0.19	0.96	9.8	9.36	0.18	<0.2	9.9
	QC Standard (expected)	0.20	1.00	10.0	10.0	0.20	<0.2	10.0
	Repeat BH-1	<0.01	9.80	5.3	10.8	0.48	<0.2	15.1

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905655 Status: Final

Type	Sample	Ni ICAP mg/L	P ICAP mg/L	Pb ICAP mg/L	Si ICAP mg/L	Sr ICAP mg/L	Th ICAP mg/L	Ti ICAP mg/L
water	BH-1	<0.05	0.6	<0.05	6.13	0.626	<0.05	<0.005
	BH-2	<0.05	0.8	<0.05	7.05	0.821	<0.05	<0.005
	BH-3	<0.05	1.0	<0.05	7.54	1.45	<0.05	<0.005
	BH-4	<0.05	1.0	<0.05	8.34	1.09	<0.05	<0.005
	BH-5	<0.05	1.2	<0.05	8.73	1.08	<0.05	<0.005
	BH-6	<0.05	1.2	<0.05	6.90	1.04	<0.05	<0.005
	BH-7	<0.05	0.8	<0.05	4.54	0.829	<0.05	<0.005
	BH-8	<0.05	0.9	<0.05	8.09	1.58	<0.05	<0.005
	BH-9	<0.05	0.8	<0.05	8.43	0.696	<0.05	<0.005
	BH-10	<0.05	0.8	<0.05	7.05	0.846	<0.05	<0.005
	TRIP BLANK	<0.05	<0.5	<0.05	0.06	<0.005	<0.05	<0.005
	Blank	<0.05	<0.5	<0.05	0.06	<0.005	<0.05	<0.005
	QC Standard (actual)	0.19	0.7	0.20	0.18	0.199	0.91	0.201
	QC Standard (expected)	0.20	1.0	0.20	<0.05	0.200	1.00	0.200
	Repeat BH-1	<0.05	0.7	<0.05	6.19	0.636	<0.05	<0.005

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905655 Status: Final

Type	Sample	V ICAP mg/L	Zn ICAP mg/L	Zr ICAP mg/L
water	BH-1	<0.005	0.04	<0.02
	BH-2	<0.005	0.04	<0.02
	BH-3	<0.005	0.05	<0.02
	BH-4	<0.005	0.04	<0.02
	BH-5	<0.005	0.04	<0.02
	BH-6	<0.005	0.04	<0.02
	BH-7	<0.005	0.06	<0.02
	BH-8	<0.005	0.04	<0.02
	BH-9	<0.005	0.04	<0.02
	BH-10	<0.005	0.04	<0.02
	TRIP BLANK	<0.005	0.03	<0.02
	Blank	<0.005	<0.01	<0.02
	QC Standard (actual)	0.194	0.20	<0.02
	QC Standard (expected)	0.200	0.20	<0.02
	Repeat BH-1	<0.005	0.04	<0.02

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905655 Status: Final

Abbreviations:

Analyses:

pH	:	pH using a standard electrode system
Tot. Alk.	:	Total alkalinity by titration to pH 4.5
Sp. Cond.	:	Specific Conductance measured at 25 degrees Celcius
F-	:	Fluoride ion concentration
Cl-	:	Chloride ion concentration
NO2-N	:	Nitrite ion concentration expressed as nitrogen
PO4-3	:	Phosphate ion concentration
Br-	:	Bromide ion concentration
NO3-N	:	Nitrate ion concentration expressed as nitrogen
SO4=	:	Total Sulphate ion concentration
TKN	:	Total Kjeldahl Nitrogen
NH3-N	:	Ammonia concentration expressed as nitrogen
Total P	:	Total Phosphorus concentration
BOD	:	Biochemical Oxygen Demand
TDS	:	Total Dissolved Solids
TSS	:	Total Suspended Solids
DOC	:	Dissolved Organic Carbon
Phenols	:	Phenolic compounds determined using the 4-AAP method
C-Hard.	:	Hardness calculated from major ion concentrations
Ag	:	Silver concentration
Al	:	Aluminum concentration

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905655 Status: Final

B	:	Boron concentration
Ba	:	Barium concentration
Be	:	Beryllium concentration
Ca	:	Calcium concentration
Cd	:	Cadmium concentration
Co	:	Cobalt concentration
Cr	:	Chromium concentration
Cu	:	Copper concentration
Fe	:	Total Iron Concentration
K	:	Potassium concentration
Mg	:	Magnesium concentration
Mn	:	Manganese concentration
Mo	:	Molybdenum concentration
Na	:	Sodium concentration
Ni	:	Nickel concentration
P	:	Phosphorus concentration
Pb	:	Lead concentration
Si	:	Silicon concentration
Sr	:	Strontium concentration
Th	:	Thorium concentration
Ti	:	Titanium concentration
V	:	Vanadium concentration
Zn	:	Zinc concentration
Zr	:	Zirconium concentration

Methods:

pH Elec. : Standard pH electrode and meter used

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

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Titr. 1	:	Titration with standardized H_2SO_4
SS Elec.	:	Stainless steel electrode in Radiometer Cond. Meter
IC	:	Ion Chromatography
A. Col.	:	Automated Colourimetry
DO Elec.	:	Dissolved Oxygen Electrode
Grav.	:	Gravimetric determination by weight
4-AAP	:	Colourimetry using 4-AAP method
Calc.	:	Result obtained by calculation from available data
ICAP	:	Inductively-Coupled Argon Plasma Spectroscopy

Units:

pH Units	:	Usual units for pH measurement
mg $CaCO_3$/L	:	Expressed as equivalent milligrams $CaCO_3$ per Liter
umhos/cm	:	Micromhos per centimeter - used for conductance
mg/L	:	Milligrams per Liter

Quality control:

< : Result obtained was below the detection limit

Signed: ....
Agnes Love, B.Sc.
Supervisor, Environmental Inorganic Services

W.O.# : 90-5655

DATE : JUN.27, 1990

MATRIX : WATER

ND = NOT DETECTED   DF=DILUTION FACTOR

	ORGANOCHLORINE COMPOUNDS	M.D.L. ug/L	BH6	BH7	BH8	BH9	BH10	TRAVEL BLANK
1	ALDRIN	0.0010	ND	ND	0.029	ND	ND	ND
2	ALPHA-BHC	0.0010	0.006	ND	0.006	ND	ND	ND
3	BETA-BHC	0.0020	ND	ND	ND	0.018	ND	ND
4	DELTA-BHC	0.0010	ND	ND	ND	ND	ND	ND
5	GAMMA-BHC	0.0010	ND	ND	ND	ND	ND	ND
6	CHLORDANE	0.0200	ND	ND	ND	ND	ND	ND
7	4,4'-DDD	0.0020	ND	ND	ND	ND	ND	ND
8	4,4'-DDE	0.0010	ND	ND	ND	ND	ND	ND
9	4,4'-DDT	0.0020	ND	ND	ND	ND	ND	ND
10	2,4'-DDT	0.0020	ND	ND	ND	ND	ND	ND
11	DIELDRIN	0.0010	ND	ND	ND	ND	ND	ND
12	ENDOSULFAN I	0.0020	ND	ND	ND	ND	0.005	ND
13	ENDOSULFAN II	0.0020	ND	ND	ND	ND	ND	ND
14	ENDOSULFAN SULPHATE	0.0020	ND	ND	ND	ND	ND	ND
15	ENDRIN	0.0020	ND	ND	ND	ND	ND	ND
16	ENDRIN ALDEHYDE	0.0040	ND	ND	ND	ND	ND	ND
17	HEPTACHLOR	0.0010	0.013	ND	ND	ND	ND	ND
18	HEPTACHLOR EPOXIDE	0.0010	ND	ND	ND	ND	ND	ND
19	METHOXYCHLOR	0.0030	ND	ND	ND	ND	ND	ND
20	MIREX	0.0020	ND	ND	ND	ND	ND	ND
21	TOXAPHENE	0.0600	ND	ND	ND	ND	ND	ND
22	TOTAL PCB'S	0.0200	ND	ND	ND	ND	ND	ND

DATE : JUN.27, 1990

W.O.# : 90-5655
MATRIX : WATER

ND = NOT DETECTED   DF=DILUTION FACTOR

	ORGANOCHLORINE COMPOUNDS	M.D.L. ug/L	REAGENT BLANK	BH1	BH1 REPEAT	BH2	BH3	BH4	BH5
1	ALDRIN	0.0010	ND	ND	ND	ND	ND	ND	ND
2	ALPHA-BHC	0.0010	ND	ND	ND	0.008	ND	0.005	0.008
3	BETA-BHC	0.0020	ND	ND	ND	ND	0.007	ND	ND
4	DELTA-BHC	0.0010	ND	ND	ND	ND	ND	ND	ND
5	GAMMA-BHC	0.0010	ND	ND	ND	0.009	ND	ND	0.009
6	CHLORDANE	0.0200	ND	ND	ND	ND	ND	ND	ND
7	4,4'-DDD	0.0020	ND	ND	ND	ND	ND	ND	ND
8	4,4'-DDE	0.0010	ND	ND	ND	ND	ND	ND	ND
9	4,4'-DDT	0.0020	ND	ND	ND	ND	ND	ND	ND
10	2,4'-DDT	0.0020	ND	ND	ND	ND	ND	ND	ND
11	DIELDRIN	0.0010	ND	ND	ND	ND	ND	ND	ND
12	ENDOSULFAN I	0.0020	ND	ND	ND	ND	ND	ND	ND
13	ENDOSULFAN II	0.0020	ND	ND	ND	ND	ND	ND	ND
14	ENDOSULFAN SULPHATE	0.0020	ND	ND	ND	ND	ND	ND	ND
15	ENDRIN	0.0020	ND	ND	ND	ND	ND	ND	ND
16	ENDRIN ALDEHYDE	0.0040	ND	ND	ND	ND	ND	ND	ND
17	HEPTACHLOR	0.0010	ND	ND	ND	ND	ND	ND	ND
18	HEPTACHLOR EPOXIDE	0.0010	ND	ND	ND	ND	ND	ND	ND
19	METHOXYCHLOR	0.0030	ND	ND	ND	ND	ND	ND	ND
20	MIREX	0.0020	ND	ND	ND	ND	ND	ND	ND
21	TOXAPHENE	0.0600	ND	ND	ND	ND	ND	ND	ND
22	TOTAL PCB'S	0.0200	ND	ND	ND	ND	ND	ND	ND

DATE : JUN.27, 1990

W.D.# : 90-5655
MATRIX : WATER

ND = NOT DETECTED   DF=DILUTION FACTOR

PERCENT RECOVERIES OF SPIKED SAMPLES

ORGANOCHLORINE COMPOUNDS

		AMOUNT SPIKED ug/L	REAGENT BLANK SPIKED	BH2 SPIKED
1	ALDRIN	0.003	92%	--
2	ALPHA-BHC	0.003	104%	80%
3	BETA-BHC	0.003	144%	140%
4	DELTA-BHC	0.003	105%	87%
5	GAMMA-BHC	0.003	97%	74%
6	CHLORDANE	--	--	--
7	4,4'-DDD	0.018	96%	104%
8	4,4'-DDE	0.006	97%	105%
9	4,4'-DDT	0.018	96%	108%
10	2,4'-DDT	0.018	86%	101%
11	DIELDRIN	0.006	117%	74%
12	ENDOSULFAN I	0.006	111%	77%
13	ENDOSULFAN II	0.006	64%	62%
14	ENDOSULFAN SULPHATE	0.018	52%	71%
15	ENDRIN	0.006	108%	71%
16	ENDRIN ALDEHYDE	0.018	92%	65%
17	HEPTACHLOR	0.003	96%	--
18	HEPTACHLOR EPOXIDE	0.003	118%	77%
19	METHOXYCHLOR	0.018	131%	72%
20	MIREX	0.018	102%	86%
21	TOXAPHENE	--	--	--
22	TOTAL PCB'S	--	--	--

RESULTS FROM AUGUST SAMPLING EVENT

10-Oct-90

Page: 1
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Attn: Ms. Cynthia Russel
Project: 90-119

PO #:

Received: 31-Aug-90 14:03

Job: 906617

Status: Final

Water Samples

Sample Id	pH pH Elec. pH Units	Tot. Alk. Titr. 1 mg CaCO3/L	Sp. Cond. SS Elec. umhos/cm	F- IC mg/L	Cl- IC mg/L	NO2-N IC mg/L	Br- IC mg/L	PO4-3 IC mg/L
BH-1	7.65	497.	948	0.12	32.7	<0.20	<0.05	<0.1
BH-2	7.10	658.	1207	<0.10	33.6	<0.20	1.27	<0.1
BH-3	7.76	969.	1830	0.17	81.2	<0.20	1.32	<0.1
BH-4	7.16	1260.	2890	<0.10	286.	<0.20	1.85	<0.1
BH-5	6.93	978.	1760	0.11	48.4	<0.20	0.54	<0.1
BH-6	7.14	792.	2800	0.15	503.	<0.20	1.26	<0.1
BH-7	7.46	517.	1161	0.17	105.	<0.20	0.64	<0.1
BH-8	7.75	742.	1780	<0.10	188.	<0.20	2.35	<0.1
BH-9	7.38	608.	1420	<0.10	111.	<0.20	0.48	<0.1
Blank	5.31	0.8	1	<0.10	<0.01	<0.20	<0.05	<0.1
QC Standard (actual)	4.46	250.	718	0.58	25.5	1.10	1.92	1.9
QC Standard (expected)	4.45	360.	718	0.60	25.0	1.00	2.00	2.0
Repeat BH-1	7.78	497.	955	0.12	31.1	<0.20	<0.05	<0.1

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Water Samples

Sample Id	NO3-N IC mg/L	SO4= IC mg/L	TDS Grav. mg/L	NH3-N A. Col. mg/L	TKN A. Col. mg/L	Total P A. Col. mg/L	DOC A. Col. mg/L	Phenols 4-AAP mg/L
BH-1	<0.02	10.6	624	10.9	13.0	0.118	20.0	0.0040
BH-2	<0.02	<0.05	688	16.4	36.0	0.280	21.0	0.0040
BH-3	<0.02	26.7	1266	15.4	22.0	0.160	39.0	0.0045
BH-4	<0.02	0.45	1594	88.0	112.	0.065	52.0	0.0160
BH-5	<0.02	0.18	988	44.0	50.0	0.580	38.0	0.0140
BH-6	<0.02	1.16	1576	27.0	30.0	0.450	24.0	0.0030
BH-7	<0.02	31.0	860	4.70	6.30	0.330	26.0	0.0025
BH-8	<0.02	0.46	980	33.0	36.0	0.300	24.0	0.0070
BH-9	<0.02	0.66	641	57.0	58.0	0.280	19.0	0.0060
Blank	<0.02	<0.05	<1	<0.02	<0.02	<0.002	<0.2	<0.0005
QC Standard (actual)	0.44	2.03	758	1.54	1.40	0.138	10.4	0.0100
QC Standard (expected)	0.44	2.00	750	1.50	1.40	0.140	10.0	0.0100
Repeat BH-1	<0.02	10.9	600	11.0	13.0	0.115	20.0	0.0040

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Water Samples

Sample Id	BOD DO Elec. mg/L	C-Hard. Calc. mg CaCO3/L	Ag ICAP mg/L	Al ICAP mg/L	B ICAP mg/L	Ba ICAP mg/L	Be ICAP mg/L	Ca ICAP mg/L
BH-1	10.8	509.7	<0.0003	0.042	0.189	0.315	<0.00003	180.
BH-2	151.	510.7	<0.0003	0.021	0.243	0.336	<0.00003	178.
BH-3	121.	805.9	<0.0003	0.154	0.314	0.277	<0.00003	273.
BH-4	520.	649.0	<0.0003	0.012	0.800	0.255	<0.00003	189.
BH-5	325.	745.9	<0.0003	0.111	0.392	0.282	<0.00003	262.
BH-6	139.	643.8	<0.0003	0.015	0.231	0.246	<0.00003	224.
BH-7	61.5	486.2	<0.0003	0.022	0.204	0.312	<0.00003	164.
BH-8	174.	609.2	<0.0003	0.029	0.405	0.420	<0.00003	202.
BH-9	325.	409.9	<0.0003	0.013	0.350	0.601	<0.00003	140.
Blank	0.4	0.2	<0.0003	0.003	<0.0050	<0.0003	<0.00003	0.063
QC Standard (actual)	5.8	33.3	<0.0003	1.08	0.259	0.0027	0.0203	10.1
QC Standard (expected)	6.0	33.2	<0.0003	1.00	0.200	<0.0003	0.0200	10.0
Repeat BH-1	15.0	507.3	<0.0003	0.060	0.175	0.325	<0.00003	179.

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Water Samples

Sample Id	Cd ICAP mg/L	Co ICAP mg/L	Cr ICAP mg/L	Cu ICAP mg/L	Fe ICAP mg/L	K ICAP mg/L	Mg ICAP mg/L	Mn ICAP mg/L
BH-1	0.0014	<0.003	<0.0005	0.0009	8.67	14.9	14.4	0.395
BH-2	0.0050	0.003	<0.0005	0.0008	38.5	17.7	15.8	0.381
BH-3	0.0009	<0.003	<0.0005	0.0095	4.12	25.4	29.7	1.55
BH-4	0.0013	<0.003	0.0006	<0.0005	9.16	73.5	42.8	0.206
BH-5	0.0064	0.005	<0.0005	0.0005	43.7	28.6	21.5	0.791
BH-6	0.0031	<0.003	<0.0005	0.0070	22.8	24.1	20.2	0.914
BH-7	0.0027	<0.003	<0.0005	<0.0005	20.0	16.4	18.1	0.626
BH-8	0.0039	0.003	0.0007	0.0012	28.5	20.9	24.9	0.173
BH-9	0.0038	0.003	<0.0005	<0.0005	28.0	15.3	14.1	0.128
Blank	<0.0003	<0.003	0.0010	<0.0005	0.0081	<0.03	0.0038	<0.0005
QC Standard (actual)	0.193	0.193	0.192	0.198	0.951	10.0	1.95	0.194
QC Standard (expected)	0.200	0.200	0.200	0.200	1.00	10.0	2.00	0.200
Repeat BH-1	0.0024	<0.003	<0.0005	0.0009	17.6	14.7	14.5	0.703

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Water Samples

Sample Id	Mo ICAP mg/L	Na ICAP mg/L	Ni ICAP mg/L	P ICAP mg/L	Pb ICAP mg/L	Si ICAP mg/L	Sr ICAP mg/L	Ti ICAP mg/L
BH-1	<0.01	29.3	<0.003	0.14	<0.003	5.05	0.773	0.0028
BH-2	<0.01	27.8	<0.003	0.38	0.006	5.59	0.738	0.0030
BH-3	<0.01	72.6	<0.003	0.12	<0.003	5.67	1.31	0.0059
BH-4	<0.01	389.	<0.003	<0.03	<0.003	6.55	1.09	0.0019
BH-5	<0.01	35.2	<0.003	0.59	0.003	16.2	0.903	0.0035
BH-6	<0.01	388.	<0.003	0.21	<0.003	5.60	0.923	0.0028
BH-7	<0.01	42.7	0.007	0.30	<0.003	4.77	0.826	0.0021
BH-8	<0.01	88.3	<0.003	0.27	<0.003	6.28	1.45	0.0025
BH-9	<0.01	48.2	<0.003	0.24	0.004	6.64	0.640	0.0019
Blank	<0.01	<0.03	<0.003	<0.03	<0.003	<0.003	<0.00100	<0.0003
QC Standard (actual)	0.45	9.98	0.191	9.42	0.196	0.202	0.196	0.0305
QC Standard (expected)	0.50	10.0	0.200	10.0	0.200	0.200	0.200	0.200
Repeat BH-1	<0.01	28.9	<0.003	0.12	<0.003	5.42	0.765	0.0027

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Water Samples

Sample Id	V ICAP mg/L	Zn ICAP mg/L
BH-1	0.0029	0.0043
BH-2	0.0062	0.0072
BH-3	0.0027	0.0068
BH-4	0.0014	0.0027
BH-5	0.0068	0.0072
BH-6	0.0034	0.0061
BH-7	0.0032	0.0041
BH-8	0.0041	0.0061
BH-9	0.0040	0.0043
Blank	<0.0003	0.0012
QC Standard (actual)	0.191	0.199
QC Standard (expected)	0.200	0.200
Repeat BH-1	0.0037	0.0060

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Abbreviations:

Parameters:

pH	:	pH using a standard electrode system
Tot. Alk.	:	Total alkalinity by titration to pH 4.5
Sp. Cond.	:	Specific Conductance measured at 25 degrees Celcius
F-	:	Fluoride ion concentration
Cl-	:	Chloride ion concentration
NO2-N	:	Nitrite ion concentration expressed as nitrogen
Br-	:	Bromide ion concentration
PO4-3	:	Phosphate ion concentration
NO3-N	:	Nitrate ion concentration expressed as nitrogen
SO4=	:	Total Sulphate ion concentration
TDS	:	Total Dissolved Solids
NH3-N	:	Ammonia concentration expressed as nitrogen
TKN	:	Total Kjeldahl Nitrogen
Total P	:	Total Phosphorus concentration
DOC	:	Dissolved Organic Carbon
Phenols	:	Phenolic compounds determined using the 4-AAP method
BOD	:	Biochemical Oxygen Demand
C-Hard.	:	Hardness calculated from major ion concentrations
Ag	:	Silver concentration
Al	:	Aluminum concentration
B	:	Boron concentration

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Ba	:	Barium concentration
Be	:	Beryllium concentration
Ca	:	Calcium concentration
Cd	:	Cadmium concentration
Co	:	Cobalt concentration
Cr	:	Chromium concentration
Cu	:	Copper concentration
Fe	:	Total Iron Concentration
K	:	Potassium concentration
Mg	:	Magnesium concentration
Mn	:	Manganese concentration
Mo	:	Molybdenum concentration
Na	:	Sodium concentration
Ni	:	Nickel concentration
P	:	Phosphorus concentration
Pb	:	Lead concentration
Si	:	Silicon concentration
Sr	:	Strontium concentration
Ti	:	Titanium concentration
V	:	Vanadium concentration
Zn	:	Zinc concentration

Methods:

pH Elec.	:	Standard pH electrode and meter used
Titr. 1	:	Titration with standardized H_2SO_4

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SS Elec.	:	Stainless steel electrode in Radiometer Cond. Meter
IC	:	Ion Chromatography
Grav.	:	Gravimetric determination by weight
A. Col.	:	Automated Colourimetry
4-AAP	:	Colourimetry using 4-AAP method
DO Elec.	:	Dissolved Oxygen Electrode
Calc.	:	Result obtained by calculation from available data
ICAP	:	Inductively-Coupled Argon Plasma Spectroscopy

Units:

pH Units	:	Usual units for pH measurement
mg $CaCO_3$/L	:	Expressed as equivalent milligrams $CaCO_3$ per Liter
umhos/cm	:	Micromhos per centimeter - used for conductance
mg/L	:	Milligrams per Liter

Quality control:

<	:	Result obtained was below the detection limit

Signed:
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Agnes Love, B.Sc.
Supervisor, Environmental Inorganic Services

VOLATILE ORGANICS RESULTS (EPA 624) DATE: 21-Sep-90

PROJECT REF #90-119
W.O. # 90-6617V
MATRIX:WATER

ND = NOT DETECTED

UNITS: MICROGRAMS/LITER (UG/L)

	COMPOUND	M.D.L. UG/L	REAGENT BLANK	BH-1	BH-1 REPEAT	BH-2	BH-3	BH-4	BH-5
1	CHLOROMETHANE	2.0	ND	ND	ND	ND	ND	ND	ND
2	VINYL CHLORIDE	2.0	ND	3.1	3.6	ND	ND	ND	ND
3	BROMOMETHANE	2.0	ND	ND	ND	ND	ND	ND	ND
4	CHLOROETHANE	5.0	ND	ND	ND	ND	ND	ND	ND
5	TRICHLOROFLUOROMETHANE	1.0	ND	ND	ND	ND	ND	ND	ND
6	1,1-DICHLOROETHENE	0.5	ND	ND	ND	ND	ND	ND	ND
7	DICHLOROMETHANE	1.0	ND	ND	ND	ND	ND	ND	ND
8	TRANS-1,2-DICHLOROETHENE	0.2	ND	ND	ND	ND	ND	ND	ND
9	1,1-DICHLOROETHANE	0.2	ND	ND	ND	ND	ND	0.5	0.3
10	CHLOROFORM	0.2	ND	ND	ND	ND	ND	ND	ND
11	1,1,1-TRICHLOROETHANE	0.2	ND	0.5	0.5	0.3	0.3	0.6	0.3
12	CARBON TETRACHLORIDE	0.2	ND	ND	ND	ND	ND	ND	ND
13	BENZENE	0.1	ND	1.9	1.6	1.5	0.5	9.6	0.8
14	1,2-DICHLOROETHANE	0.2	ND	ND	ND	ND	ND	ND	ND
15	TRICHLOROETHENE	0.2	ND	ND	ND	ND	ND	ND	ND
16	1,2-DICHLOROPROPANE	0.2	ND	ND	ND	ND	ND	ND	ND
17	BROMODICHLOROMETHANE	0.2	ND	ND	ND	ND	ND	ND	ND
18	CIS-1,3-DICHLOROPROPENE	0.5	ND	ND	ND	ND	ND	ND	ND
19	TOLUENE	0.2	ND	0.4	0.4	0.6	0.3	1.8	2.0
20	TRANS-1,3-DICHLOROPROPENE	0.5	ND	ND	ND	ND	ND	ND	ND
21	1,1,2-TRICHLOROETHANE	0.5	ND	ND	ND	ND	ND	ND	ND
22	TETRACHLOROETHENE	0.5	ND	ND	ND	ND	ND	ND	ND
23	DIBROMOCHLOROMETHANE	1.0	ND	ND	ND	ND	ND	ND	ND
24	CHLOROBENZENE	0.2	ND	2.7	3.2	1.9	1.1	24.0	6.8
25	ETHYLBENZENE	0.2	ND	ND	ND	ND	ND	0.9	0.6
26	M-XYLENE & P-XYLENE	0.2	ND	ND	ND	0.2	ND	20.3	26.4
27	O-XYLENE	0.2	ND	ND	ND	ND	ND	0.8	1.0
28	BROMOFORM	2.0	ND	ND	ND	ND	ND	ND	ND
29	1,1,2,2-TETRACHLOROETHANE	1.0	ND	ND	ND	ND	ND	ND	ND
30	1,3-DICHLOROBENZENE	0.2	ND	ND	ND	ND	ND	ND	ND
31	1,4-DICHLOROBENZENE	0.2	ND	0.7	0.9	2.0	0.3	13.8	2.0
32	1,2-DICHLOROBENZENE	0.2	ND	ND	ND	ND	ND	1.0	ND
	SURROGATE STANDARD RECOVERIES:	AMOUNT							
33	FLUOROBENZENE	4 UG/L	107%	81%	72%	67%	61%	59%	70%
34	4-BROMOFLUOROBENZENE	3 UG/L	101%	123%	126%	103%	116%	127%	118%

VOLATILE ORGANICS RESULTS (EPA 624) DATE: 21-Sep-90

PROJECT REF #90-119
W.O. # 90-6617V ND = NOT DETECTED UNITS: MICROGRAMS/LITER (UG/L)
MATRIX:WATER

	COMPOUND	M.D.L. UG/L	BH-6	BH-7	BH-8	BH-9
1	CHLOROMETHANE	2.0	ND	ND	ND	ND
2	VINYL CHLORIDE	2.0	ND	ND	ND	ND
3	BROMOMETHANE	2.0	ND	ND	ND	ND
4	CHLOROETHANE	5.0	ND	ND	ND	ND
5	TRICHLOROFLUOROMETHANE	1.0	ND	ND	ND	ND
6	1,1-DICHLOROETHENE	0.5	ND	ND	ND	ND
7	DICHLOROMETHANE	1.0	ND	ND	ND	ND
8	TRANS-1,2-DICHLOROETHENE	0.2	ND	ND	ND	ND
9	1,1-DICHLOROETHANE	0.2	0.5	ND	ND	ND
10	CHLOROFORM	0.2	ND	ND	ND	ND
11	1,1,1-TRICHLOROETHANE	0.2	ND	0.6	0.5	ND
12	CARBON TETRACHLORIDE	0.2	ND	ND	ND	ND
13	BENZENE	0.1	2.3	ND	2.2	4.7
14	1,2-DICHLOROETHANE	0.2	ND	ND	ND	ND
15	TRICHLOROETHENE	0.2	ND	0.2	ND	ND
16	1,2-DICHLOROPROPANE	0.2	ND	ND	ND	ND
17	BROMODICHLOROMETHANE	0.2	ND	ND	ND	ND
18	CIS-1,3-DICHLOROPROPENE	0.5	ND	ND	ND	ND
19	TOLUENE	0.2	0.8	0.3	0.4	2.5
20	TRANS-1,3-DICHLOROPROPENE	0.5	ND	ND	ND	ND
21	1,1,2-TRICHLOROETHANE	0.5	ND	ND	ND	ND
22	TETRACHLOROETHENE	0.5	ND	ND	ND	ND
23	DIBROMOCHLOROMETHANE	1.0	ND	ND	ND	ND
24	CHLOROBENZENE	0.2	2.3	ND	6.9	14.7
25	ETHYLBENZENE	0.2	ND	ND	ND	0.2
26	M-XYLENE & P-XYLENE	0.2	0.2	ND	1.2	0.7
27	O-XYLENE	0.2	ND	ND	0.7	1.4
28	BROMOFORM	2.0	ND	ND	ND	ND
29	1,1,2,2-TETRACHLOROETHANE	1.0	ND	ND	ND	ND
30	1,3-DICHLOROBENZENE	0.2	ND	ND	ND	0.4
31	1,4-DICHLOROBENZENE	0.2	0.8	0.2	2.1	4.9
32	1,2-DICHLOROBENZENE	0.2	0.2	ND	0.4	1.0
	SURROGATE STANDARD RECOVERIES:	AMOUNT				
33	FLUOROBENZENE	4 UG/L	80%	88%	86%	60%
34	4-BROMOFLUOROBENZENE	3 UG/L	115%	88%	95%	114%

QUALITY CONTROL SPIKE PERCENT RECOVERIES DATE: 21-Sep-90

PROJECT REF #90-119
W.O. # 90-6617V
MATRIX:WATER

	COMPOUND	AMOUNT UG/L	REAGENT SPIKE
1	CHLOROMETHANE	10.0	83%
2	VINYL CHLORIDE	10.0	111%
3	BROMOMETHANE	10.0	98%
4	CHLOROETHANE	10.0	148%
5	TRICHLOROFLUOROMETHANE	5.0	92%
6	1,1-DICHLOROETHENE	5.0	102%
7	DICHLOROMETHANE	5.0	127%
8	TRANS-1,2-DICHLOROETHENE	5.0	103%
9	1,1-DICHLOROETHANE	5.0	109%
10	CHLOROFORM	5.0	105%
11	1,1,1-TRICHLOROETHANE	5.0	96%
12	CARBON TETRACHLORIDE	5.0	103%
13	BENZENE	5.0	106%
14	1,2-DICHLOROETHANE	5.0	102%
15	TRICHLOROETHENE	5.0	112%
16	1,2-DICHLOROPROPANE	5.0	111%
17	BROMODICHLOROMETHANE	5.0	104%
18	CIS-1,3-DICHLOROPROPENE	7.5	117%
19	TOLUENE	5.0	116%
20	TRANS-1,3-DICHLOROPROPENE	2.5	108%
21	1,1,2-TRICHLOROETHANE	5.0	113%
22	TETRACHLOROETHENE	5.0	106%
23	DIBROMOCHLOROMETHANE	5.0	109%
24	CHLOROBENZENE	5.0	108%
25	ETHYLBENZENE	5.0	121%
26	M-XYLENE & P-XYLENE	1.6	117%
27	O-XYLENE	1.6	109%
28	BROMOFORM	5.0	120%
29	1,1,2,2-TETRACHLOROETHANE	5.0	119%
30	1,3-DICHLOROBENZENE	3.1	116%
31	1,4-DICHLOROBENZENE	2.7	109%
32	1,2-DICHLOROBENZENE	3.2	115%

SURROGATE STANDARD RECOVERIES:

33	FLUOROBENZENE	3.6	101%
34	4-BROMOFLUOROBENZENE	3.0	112%

DATE : SEPT.17, 1990

W.O.# : 90-6617
MATRIX : WATER

ND = NOT DETECTED DF=DILUTION FACTOR

	ORGANOCHLORINE COMPOUNDS	M.D.L. ug/L	REAGENT BLANK	BH-1	BH-2	BH-3	BH-4	BH-5	BH-6
1	ALDRIN	0.0005	ND	ND	ND	ND	0.0008	ND	ND
2	ALPHA-BHC	0.0005	ND	ND	0.0005	ND	0.004	0.0006	ND
3	BETA-BHC	0.0010	ND	ND	ND	ND	0.0014	ND	ND
4	DELTA-BHC	0.0005	ND	ND	ND	ND	0.0009	0.0013	ND
5	GAMMA-BHC	0.0005	ND	ND	0.0028	ND	ND	ND	ND
6	CHLORDANE	0.0100	ND	ND	ND	ND	ND	ND	ND
7	4,4'-DDD	0.0010	ND	ND	ND	ND	ND	ND	ND
8	4,4'-DDE	0.0005	ND	ND	ND	ND	ND	ND	ND
9	4,4'-DDT	0.0010	ND	ND	ND	ND	ND	ND	ND
10	2,4'-DDT	0.0010	ND	ND	ND	ND	ND	ND	ND
11	DIELDRIN	0.0005	ND	ND	ND	ND	ND	ND	ND
12	ENDOSULFAN I	0.0010	ND	ND	ND	ND	ND	ND	ND
13	ENDOSULFAN II	0.0005	ND	ND	ND	ND	ND	ND	ND
14	ENDOSULFAN SULPHATE	0.0010	ND	ND	ND	ND	ND	ND	ND
15	ENDRIN	0.0010	ND	ND	ND	ND	ND	ND	ND
16	ENDRIN ALDEHYDE	0.0020	ND	ND	ND	ND	ND	ND	ND
17	HEPTACHLOR	0.0005	ND	ND	ND	ND	0.0035	ND	ND
18	HEPTACHLOR EPOXIDE	0.0005	ND	ND	ND	ND	ND	ND	ND
19	METHOXYCHLOR	0.0015	ND	ND	ND	ND	ND	ND	ND
20	MIREX	0.0010	ND	ND	ND	ND	ND	ND	ND
21	TOXAPHENE	0.0300	ND	ND	ND	ND	ND	ND	ND
22	TOTAL PCB'S	0.0100	ND	ND	ND	ND	ND	ND	ND

DATE : SEPT.17, 1990

W.O.# : 90-6617
MATRIX : WATER

ND = NOT DETECTED   DF=DILUTION FACTOR

	ORGANOCHLORINE COMPOUNDS	M.D.L. ug/L	BH-7	BH-8	BH-9
1	ALDRIN	0.0005	ND	0.0076	0.013
2	ALPHA-BHC	0.0005	ND	0.0049	0.0049
3	BETA-BHC	0.0010	ND	ND	ND
4	DELTA-BHC	0.0005	ND	0.0033	0.0031
5	GAMMA-BHC	0.0005	ND	ND	0.0032
6	CHLORDANE	0.0100	ND	0.015	ND
7	4,4'-DDD	0.0010	ND	0.0038	ND
8	4,4'-DDE	0.0005	ND	ND	ND
9	4,4'-DDT	0.0010	ND	ND	ND
10	2,4'-DDT	0.0010	ND	ND	ND
11	DIELDRIN	0.0005	ND	ND	ND
12	ENDOSULFAN I	0.0010	ND	ND	ND
13	ENDOSULFAN II	0.0005	ND	ND	ND
14	ENDOSULFAN SULPHATE	0.0010	ND	ND	ND
15	ENDRIN	0.0010	ND	ND	ND
16	ENDRIN ALDEHYDE	0.0020	ND	ND	ND
17	HEPTACHLOR	0.0005	ND	ND	ND
18	HEPTACHLOR EPOXIDE	0.0005	ND	ND	ND
19	METHOXYCHLOR	0.0015	ND	ND	ND
20	MIREX	0.0010	ND	ND	ND
21	TOXAPHENE	0.0300	ND	ND	ND
22	TOTAL PCB'S	0.0100	ND	ND	ND

DATE : SEPT.17, 1990

W.O.# : 90-6617
MATRIX : WATER

ND = NOT DETECTED DF=DILUTION FACTOR

PERCENT RECOVERIES OF SPIKED SAMPLES

ORGANOCHLORINE COMPOUNDS

		AMOUNT SPIKED ug/L	REAGENT BLANK SPIKED
1	ALDRIN	0.003	140%
2	ALPHA-BHC	0.003	138%
3	BETA-BHC	0.003	113%
4	DELTA-BHC	0.003	128%
5	GAMMA-BHC	0.003	124%
6	CHLORDANE	--	--
7	4,4'-DDD	0.018	142%
8	4,4'-DDE	0.006	132%
9	4,4'-DDT	0.018	140%
10	2,4'-DDT	0.018	140%
11	DIELDRIN	0.006	40%
12	ENDOSULFAN I	0.006	42%
13	ENDOSULFAN II	0.006	20%
14	ENDOSULFAN SULPHATE	0.018	19%
15	ENDRIN	0.006	49%
16	ENDRIN ALDEHYDE	0.018	37%
17	HEPTACHLOR	0.003	138%
18	HEPTACHLOR EPOXIDE	0.003	61%
19	METHOXYCHLOR	0.018	22%
20	MIREX	0.018	139%
21	TOXAPHENE	--	--
22	TOTAL PCB'S	--	--

APPENDIX E

SURFACE WATER QUALITY

RESULTS FROM MAY SAMPLING EVENT

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905658 Status: Final

Type	Sample	Na ICAP mg/L	Ni ICAP mg/L	P ICAP mg/L	Pb ICAP mg/L	Sr ICAP mg/L	Th ICAP mg/L	Ti ICAP mg/L
water	SW-3	207.	<0.003	0.05	0.007	0.609	<0.003	<0.0003
	SW-4	155.	0.003	0.16	0.017	0.836	<0.003	<0.0003
	SW-5	20.9	0.003	0.15	0.006	0.332	<0.003	0.0042
	SW-6	4.3	<0.003	0.03	<0.003	0.272	<0.003	<0.0003
	SW-7	4.4	<0.003	0.06	0.004	0.254	<0.003	0.0029
	SW-8	4.9	<0.003	<0.03	0.003	0.250	<0.003	<0.0003
	SW-9	6.6	<0.003	0.04	<0.003	0.109	0.003	<0.0003
	SW-10	160.	0.003	0.11	0.009	0.800	<0.003	<0.0003
	Blank	<0.5	<0.003	<0.03	<0.003	0.00009	<0.003	<0.0003
	QC Standard (actual)	12.0	0.169	0.27	0.174	0.181	0.321	0.0865
	QC Standard (expected)	10.0	0.200	0.40	0.200	0.200	0.400	0.200
	Repeat SW-3	210.	<0.003	0.04	0.007	0.606	<0.003	<0.0003

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905658 Status: Final

Type	Sample	V ICAP mg/L	Zn ICAP mg/L	Zr ICAP mg/L
water	SW-3	0.0005	0.0437	<0.001
	SW-4	0.0011	0.478	<0.001
	SW-5	0.0010	0.0306	<0.001
	SW-6	0.0004	0.0131	<0.001
	SW-7	0.0008	0.0167	<0.001
	SW-8	0.0005	0.0142	<0.001
	SW-9	0.0005	0.0114	<0.001
	SW-10	0.0007	0.392	<0.001
	Blank	<0.0003	0.0011	<0.001
	QC Standard (actual)	0.176	0.167	0.083
	QC Standard (expected)	0.200	0.200	0.200
	Repeat SW-3	0.0007	0.0418	<0.001

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905658 Status: Final

Abbreviations:

Analyses:

pH	:	pH using a standard electrode system
Tot. Alk.	:	Total alkalinity by titration to pH 4.5
Sp. Cond.	:	Specific Conductance measured at 25 degrees Celcius
F-	:	Fluoride ion concentration
Cl-	:	Chloride ion concentration
NO2-N	:	Nitrite ion concentration expressed as nitrogen
PO4-3	:	Phosphate ion concentration
Br-	:	Bromide ion concentration
NO3-N	:	Nitrate ion concentration expressed as nitrogen
SO4=	:	Total Sulphate ion concentration
TKN	:	Total Kjeldahl Nitrogen
NH3-N	:	Ammonia concentration expressed as nitrogen
Total P	:	Total Phosphorus concentration
BOD	:	Biochemical Oxygen Demand
DOC	:	Dissolved Organic Carbon
TOC	:	Total Organic Carbon
TDS	:	Total Dissolved Solids
TSS	:	Total Suspended Solids
Phenols	:	Phenolic compounds determined using the 4-AAP method
C-Hard.	:	Hardness calculated from major ion concentrations
Ag	:	Silver concentration

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905658 Status: Final

Al	:	Aluminum concentration
B	:	Boron concentration
Ba	:	Barium concentration
Be	:	Beryllium concentration
Ca	:	Calcium concentration
Cd	:	Cadmium concentration
Co	:	Cobalt concentration
Cr	:	Chromium concentration
Cu	:	Copper concentration
Fe	:	Total Iron Concentration
K	:	Potassium concentration
Mg	:	Magnesium concentration
Mn	:	Manganese concentration
Mo	:	Molybdenum concentration
Na	:	Sodium concentration
Ni	:	Nickel concentration
P	:	Phosphorus concentration
Pb	:	Lead concentration
Sr	:	Strontium concentration
Th	:	Thorium concentration
Ti	:	Titanium concentration
V	:	Vanadium concentration
Zn	:	Zinc concentration
Zr	:	Zirconium concentration

Methods:

pH Elec. : Standard pH electrode and meter used

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905658 Status: Final

Titr. 1	:	Titration with standardized H_2SO_4
SS Elec.	:	Stainless steel electrode in Radiometer Cond. Meter
IC	:	Ion Chromatography
A. Col.	:	Automated Colourimetry
DO Elec.	:	Dissolved Oxygen Electrode
Grav.	:	Gravimetric determination by weight
4-AAP	:	Colourimetry using 4-AAP method
Calc.	:	Result obtained by calculation from available data
ICAP	:	Inductively-Coupled Argon Plasma Spectroscopy

Units:

pH Units	:	Usual units for pH measurement
mg $CaCO_3$/L	:	Expressed as equivalent milligrams $CaCO_3$ per Liter
umhos/cm	:	Micromhos per centimeter - used for conductance
mg/L	:	Milligrams per Liter

Quality control:

< : Result obtained was below the detection limit

Signed: ....
Agnes Love, B.Sc.
Supervisor, Environmental Inorganic Services

DATE : JUN.27, 1990

W.O.# : 90-5658
MATRIX : WATER

ND = NOT DETECTED   DF=DILUTION FACTOR

	ORGANOCHLORINE COMPOUNDS	M.D.L. ug/L	REAGENT BLANK	SW-3	SW-3 REPEAT	SW-4	SW-5	SW-6	SW-7
1	ALDRIN	0.0010	ND	ND	ND	ND	ND	ND	ND
2	ALPHA-BHC	0.0010	ND	ND	ND	ND	ND	ND	0.002
3	BETA-BHC	0.0020	ND	0.003	0.003	ND	ND	ND	0.003
4	DELTA-BHC	0.0010	ND	ND	ND	ND	ND	ND	ND
5	GAMMA-BHC	0.0010	ND	ND	ND	ND	ND	ND	ND
6	CHLORDANE	0.0200	ND	ND	ND	ND	ND	ND	ND
7	4,4'-DDD	0.0020	ND	ND	ND	ND	ND	ND	ND
8	4,4'-DDE	0.0010	ND	ND	ND	ND	ND	ND	ND
9	4,4'-DDT	0.0020	ND	ND	ND	ND	ND	ND	ND
10	2,4'-DDT	0.0020	ND	ND	ND	ND	ND	ND	ND
11	DIELDRIN	0.0010	ND	ND	ND	ND	ND	ND	ND
12	ENDOSULFAN I	0.0020	ND	ND	ND	ND	ND	ND	ND
13	ENDOSULFAN II	0.0020	ND	ND	ND	ND	ND	ND	ND
14	ENDOSULFAN SULPHATE	0.0020	ND	ND	ND	ND	ND	ND	ND
15	ENDRIN	0.0020	ND	ND	ND	ND	ND	ND	ND
16	ENDRIN ALDEHYDE	0.0040	ND	ND	ND	ND	ND	ND	ND
17	HEPTACHLOR	0.0010	ND	ND	ND	ND	ND	ND	ND
18	HEPTACHLOR EPOXIDE	0.0010	ND	ND	ND	ND	ND	ND	ND
19	METHOXYCHLOR	0.0030	ND	ND	ND	ND	ND	ND	ND
20	MIREX	0.0020	ND	ND	ND	ND	ND	ND	ND
21	TOXAPHENE	0.0600	ND	ND	ND	ND	ND	ND	ND
22	TOTAL PCB'S	0.0200	ND	ND	ND	ND	ND	ND	ND

DATE : JUN.27, 1990

W.O.# : 90-5658
MATRIX : WATER

ND = NOT DETECTED   DF=DILUTION FACTOR

	ORGANOCHLORINE COMPOUNDS	M.D.L. ug/L	SW-8	SW-9	SW-10
1	ALDRIN	0.0010	ND	ND	ND
2	ALPHA-BHC	0.0010	0.002	0.004	0.002
3	BETA-BHC	0.0020	ND	ND	ND
4	DELTA-BHC	0.0010	ND	0.001	ND
5	GAMMA-BHC	0.0010	ND	ND	ND
6	CHLORDANE	0.0200	ND	ND	ND
7	4,4'-DDD	0.0020	ND	ND	ND
8	4,4'-DDE	0.0010	ND	ND	ND
9	4,4'-DDT	0.0020	ND	ND	ND
10	2,4'-DDT	0.0020	ND	ND	ND
11	DIELDRIN	0.0010	ND	ND	ND
12	ENDOSULFAN I	0.0020	ND	ND	ND
13	ENDOSULFAN II	0.0020	ND	ND	ND
14	ENDOSULFAN SULPHATE	0.0020	ND	ND	ND
15	ENDRIN	0.0020	ND	ND	ND
16	ENDRIN ALDEHYDE	0.0040	ND	ND	ND
17	HEPTACHLOR	0.0010	ND	ND	ND
18	HEPTACHLOR EPOXIDE	0.0010	ND	ND	ND
19	METHOXYCHLOR	0.0030	ND	ND	ND
20	MIREX	0.0020	ND	ND	ND
21	TOXAPHENE	0.0600	ND	ND	ND
22	TOTAL PCB'S	0.0200	ND	ND	ND

DATE : JUN.27, 1990

W.O.# : 90-5658
MATRIX : WATER

ND = NOT DETECTED DF=DILUTION FACTOR

PERCENT RECOVERIES OF SPIKED SAMPLES

ORGANOCHLORINE COMPOUNDS

		AMOUNT SPIKED ug/L	REAGENT BLANK SPIKED	SW-4 SPIKED
1	ALDRIN	0.003	79%	65%
2	ALPHA-BHC	0.003	116%	85%
3	BETA-BHC	0.003	73%	62%
4	DELTA-BHC	0.003	83%	93%
5	GAMMA-BHC	0.003	71%	122%
6	CHLORDANE	--	--	--
7	4,4'-DDD	0.018	80%	85%
8	4,4'-DDE	0.006	74%	78%
9	4,4'-DDT	0.018	81%	81%
10	2,4'-DDT	0.018	77%	79%
11	DIELDRIN	0.006	68%	84%
12	ENDOSULFAN I	0.006	68%	96%
13	ENDOSULFAN II	0.006	74%	88%
14	ENDOSULFAN SULPHATE	0.018	51%	61%
15	ENDRIN	0.006	66%	75%
16	ENDRIN ALDEHYDE	0.018	58%	54%
17	HEPTACHLOR	0.003	97%	69%
18	HEPTACHLOR EPOXIDE	0.003	70%	90%
19	METHOXYCHLOR	0.018	81%	93%
20	MIREX	0.018	75%	70%
21	TOXAPHENE	--	--	--
22	TOTAL PCB'S	--	--	--

RESULTS FROM AUGUST SAMPLING EVENT

11-Oct-90

Page: 1
Copy: 2 of 2
Set : 1

Attn: Ms. Cynthia Russel
Project: 90-119 PO #:

Received: 31-Aug-90 14:02

Job: 906616 Status: Final

Water Samples

Sample Id	pH pH Elec. pH Units	Tot. Alk. Titr. 1 mg CaCO3/L	Sp. Cond. SS Elec. umhos/cm	F- IC mg/L	Cl- IC mg/L	NO2-N IC mg/L	Br- IC mg/L	PO4-3 IC mg/L
SW-4	7.55	387.	931	0.27	90.9	<0.20	<0.05	<0.1
SW-5	8.68	80.5	194	<0.10	12.4	<0.20	<0.05	<0.1
SW-6	7.54	112.	251	<0.10	12.2	<0.20	<0.05	<0.1
SW-7	7.77	111.	247	<0.10	12.4	<0.20	<0.05	<0.1
SW-8	7.32	106.	239	<0.10	13.0	<0.20	<0.05	<0.1
SW-9	7.43	112.	260	0.13	16.5	<0.20	<0.05	<0.1
SW-10	7.65	113.	250	<0.10	12.6	<0.20	<0.05	<0.1
SW-11	7.48	118.	246	<0.10	10.1	<0.20	<0.05	<0.1
SW-12	7.38	112.	252	<0.10	12.7	<0.20	<0.05	<0.1
SW-13	7.56	109.	250	<0.10	13.0	<0.20	<0.05	<0.1
SW-14	7.54	114.	253	<0.10	12.3	<0.20	<0.05	<0.1
SW-15	7.77	110.	245	<0.10	12.4	<0.20	<0.05	<0.1
SW-16	7.82	105.	244	<0.10	13.4	<0.20	<0.05	<0.1
SW-17	7.82	107.	247	<0.10	12.8	<0.20	<0.05	<0.1
Blank	5.31	0.8	1	<0.10	<0.01	<0.02	<0.05	<0.1
QC Standard (actual)	4.46	250.	718	0.60	26.2	1.14	2.01	1.8
QC Standard (expected)	4.45	250.	718	0.60	25.0	1.00	2.00	2.0
Repeat SW-4	7.63	387.	928	0.27	93.1	<0.20	<0.05	<0.1

Attn: Ms. Cynthia Russel
Project: 90-119 PO #:

Received: 31-Aug-90 14:02

Job: 906616 Status: Final

Water Samples

Sample Id	NO3-N IC mg/L	SO4= IC mg/L	TDS Grav. mg/L	NH3-N A. Col. mg/L	TKN A. Col. mg/L	Total P A. Col. mg/L	DOC A. Col. mg/L	TOC A. Col. mg/L
SW-4	<0.02	13.4	613	0.72	2.90	0.260	12.0	13.0
SW-5	<0.02	9.85	130	0.09	0.67	0.033	6.4	7.5
SW-6	<0.02	9.73	168	0.04	0.83	0.055	6.5	7.6
SW-7	<0.02	89.8	160	0.03	0.79	0.047	6.3	6.9
SW-8	<0.02	10.4	161	0.03	0.98	0.055	6.3	6.5
SW-9	<0.02	10.4	166	0.14	1.02	0.052	6.5	7.8
SW-10	<0.02	10.0	176	<0.02	0.78	0.052	6.8	6.9
SW-11	<0.02	8.89	160	<0.02	0.65	0.036	7.0	7.4
SW-12	<0.02	10.1	184	<0.02	0.87	0.055	6.3	6.9
SW-13	<0.02	10.5	177	<0.02	1.03	0.052	6.5	6.7
SW-14	<0.02	9.77	170	0.02	0.94	0.052	6.8	7.0
SW-15	<0.02	9.74	176	0.02	0.81	0.047	6.5	9.0
SW-16	<0.02	10.3	169	<0.02	0.93	0.070	6.2	7.2
SW-17	<0.02	10.5	178	<0.02	0.92	0.048	6.0	7.0
Blank	<0.02	<0.05	<1	<0.02	<0.02	<0.002	<0.2	<0.2
QC Standard (actual)	0.43	61.7	257	0.32	0.81	0.086	5.3	5.3
QC Standard (expected)	0.44	60.0	250	0.30	0.84	0.084	5.0	5.0
Repeat SW-4	<0.02	13.7	621	0.70	2.50	0.310	12.0	12.5

Attn: Ms. Cynthia Russel
Project: 90-119 PO #:

Received: 31-Aug-90 14:02

Job: 906616 Status: Final

Water Samples

Sample Id	Phenols 4-AAP mg/L	TSS Grav. mg/L	BOD DO Elec. mg/L	C-Hard. Calc. mg CaCO3/L	Ag ICAP mg/L	Al ICAP mg/L	B ICAP mg/L	Ba ICAP mg/L
SW-4	<0.0005	5.40	8.2	408.3	<0.0003	0.133	0.196	0.204
SW-5	0.0005	2.75	1.4	97.0	<0.0003	0.028	0.0167	0.0332
SW-6	<0.0005	5.05	0.5	129.2	<0.0003	0.040	0.0088	0.0457
SW-7	<0.0005	5.20	0.7	127.3	<0.0003	0.030	<0.0050	0.0441
SW-8	<0.0005	9.05	1.3	123.1	<0.0003	0.066	<0.0050	0.0356
SW-9	<0.0005	8.35	1.7	128.3	<0.0003	0.374	0.0069	0.0395
SW-10	<0.0005	8.30	1.1	130.1	<0.0003	0.057	<0.0050	0.0443
SW-11	<0.0005	1.75	4.0	128.0	<0.0003	0.021	<0.0050	0.0535
SW-12	<0.0005	7.90	1.4	126.9	<0.0003	0.058	0.0054	0.0443
SW-13	<0.0005	8.25	1.8	124.8	<0.0003	0.056	0.0091	0.0368
SW-14	0.0005	8.10	1.3	127.7	<0.0003	0.046	0.0060	0.0472
SW-15	0.0005	8.65	0.9	126.7	<0.0003	0.068	<0.0050	0.0467
SW-16	0.0020	12.20	2.0	123.8	<0.0003	0.076	0.0076	0.0369
SW-17	0.0005	8.35	0.8	124.8	<0.0003	0.072	0.0099	0.0360
Blank	<0.0005	<0.05	0.3	1.0	<0.0003	<0.003	<0.0050	<0.0003
QC Standard (actual)	0.0095	9.30	2.2	33.3	<0.0003	1.19	0.253	0.0143
QC Standard (expected)	0.0100	10.00	2.0	33.2	<0.0003	1.00	0.200	<0.0003
Repeat SW-4	<0.0005	5.80	8.0	394.0	<0.0003	0.134	0.192	0.203

Attn: Ms. Cynthia Russel
Project: 90-119
PO #:
Received: 31-Aug-90 14:02

Job: 906616 Status: Final

Water Samples

Sample Id	Be ICAP mg/L	Ca ICAP mg/L	Cd ICAP mg/L	Co ICAP mg/L	Cr ICAP mg/L	Cu ICAP mg/L	Fe ICAP mg/L	K ICAP mg/L
SW-4	<0.00030	146.	0.0007	<0.003	0.0017	0.0115	2.57	17.5
SW-5	<0.00030	31.7	<0.0003	<0.003	0.0017	0.0025	0.116	1.46
SW-6	<0.00030	44.0	<0.0003	<0.003	0.0016	0.0020	0.127	1.31
SW-7	<0.00030	43.2	<0.0003	<0.003	0.0017	0.0660	0.106	1.31
SW-8	<0.00030	42.0	<0.0003	<0.003	0.0017	0.0020	0.0886	1.33
SW-9	<0.00030	43.8	<0.0003	<0.003	0.0019	0.0021	0.245	1.59
SW-10	<0.00030	44.4	<0.0003	<0.003	0.0016	0.0020	0.154	1.32
SW-11	<0.00030	42.7	<0.0003	<0.003	0.0016	0.0018	0.0765	1.19
SW-12	<0.00030	43.1	<0.0003	<0.003	0.0016	0.0021	0.156	1.33
SW-13	<0.00030	42.7	<0.0003	<0.003	0.0017	0.0017	0.0944	1.33
SW-14	<0.00030	43.3	<0.0003	<0.003	0.0016	0.0022	0.148	1.31
SW-15	<0.00030	42.9	<0.0003	<0.003	0.0017	0.0026	0.184	1.30
SW-16	<0.00030	42.3	<0.0003	<0.003	0.0017	0.0020	0.137	1.36
SW-17	<0.00030	42.7	<0.0003	<0.003	0.0018	0.0019	0.0943	1.33
Blank	<0.00030	0.387	<0.0003	<0.003	<0.0005	<0.0005	0.0134	<0.03
QC Standard (actual)	0.0205	10.1	0.196	0.194	0.196	0.198	0.972	9.97
QC Standard (expected)	0.0200	10.0	0.200	0.200	0.200	0.200	1.00	10.0
Repeat SW-4	<0.00030	140.	0.0007	<0.003	0.0017	0.0117	2.58	17.6

Attn: Ms. Cynthia Russel
Project: 90-119 PO #:

Received: 31-Aug-90 14:02

Job: 906616 Status: Final

Water Samples

Sample Id	Mg ICAP mg/L	Mn ICAP mg/L	Mo ICAP mg/L	Na ICAP mg/L	Ni ICAP mg/L	P ICAP mg/L	Pb ICAP mg/L	Si ICAP mg/L
SW-4	10.3	0.127	<0.01	56.4	0.008	0.26	0.009	0.209
SW-5	4.31	0.0214	<0.01	6.63	0.003	0.03	0.004	0.123
SW-6	4.67	0.142	<0.01	6.11	<0.003	0.05	<0.003	0.064
SW-7	4.65	0.0950	<0.01	6.15	<0.003	0.10	<0.003	0.079
SW-8	4.35	0.0618	<0.01	6.49	<0.003	0.05	0.003	0.132
SW-9	4.55	0.0664	<0.01	7.71	<0.003	0.05	<0.003	0.159
SW-10	4.59	0.126	<0.01	6.23	<0.003	0.05	<0.003	0.086
SW-11	5.12	0.126	<0.01	5.26	<0.003	0.03	<0.003	0.032
SW-12	4.59	0.126	<0.01	6.22	<0.003	0.05	0.003	0.095
SW-13	4.34	0.0790	<0.01	6.40	<0.003	0.05	<0.003	0.089
SW-14	4.69	0.167	<0.01	5.96	<0.003	0.05	<0.003	0.140
SW-15	4.67	0.162	<0.01	6.05	<0.003	0.06	<0.003	0.112
SW-16	4.36	0.105	<0.01	6.47	<0.003	0.06	<0.003	0.063
SW-17	4.33	0.0737	<0.01	6.42	<0.003	0.05	<0.003	0.078
Blank	<0.0005	<0.0005	<0.01	<0.03	<0.003	<0.03	<0.003	<0.003
QC Standard (actual)	1.95	0.195	0.45	10.0	0.194	9.53	0.198	0.207
QC Standard (expected)	2.00	0.200	0.50	10.0	0.200	10.0	0.200	0.200
Repeat SW-4	10.3	0.127	<0.01	56.3	0.009	0.24	0.009	0.189

Attn: Ms. Cynthia Russel
Project: 90-119 PO #:

Received: 31-Aug-90 14:02

Job: 906616 Status: Final

Water Samples

Sample Id	Sr ICAP mg/L	Ti ICAP mg/L	V ICAP mg/L	Zn ICAP mg/L	Anion Sum Calc. meq/L	CAB Calc. %
SW-4	0.646	0.0066	0.0011	0.312	10.31	-3.48
SW-5	0.190	0.0010	0.0008	0.0029	1.96	-7.06
SW-6	0.228	0.0014	0.0010	0.0022	2.59	-5.24
SW-7	0.217	0.0012	0.0009	0.0022	2.58	-4.86
SW-8	0.138	0.0024	0.0012	0.0021	2.50	-5.21
SW-9	0.145	0.0026	0.0010	0.0027	2.73	-3.73
SW-10	0.207	0.0019	0.0010	0.0022	2.63	-4.89
SW-11	0.348	0.0010	0.0007	0.0021	2.66	-2.80
SW-12	0.207	0.0020	0.0010	0.0022	2.61	-4.24
SW-13	0.142	0.0017	0.0011	0.0018	2.56	-4.48
SW-14	0.241	0.0017	0.0009	0.0030	2.64	-3.77
SW-15	0.230	0.0024	0.0010	0.0039	2.56	-4.88
SW-16	0.139	0.0024	0.0011	0.0022	2.50	-5.44
SW-17	0.137	0.0019	0.0011	0.0020	2.51	-5.46
Blank	0.00197	<0.0003	<0.0003	<0.0005	0.02	-10.53
QC Standard (actual)	0.195	0.0341	0.192	0.202	5.79	61.97
QC Standard (expected)	0.200	0.200	0.200	0.200	5.75	61.87
Repeat SW-4	0.644	0.0069	0.0012	0.311	10.38	-1.86

DATE : SEPT.14, 1990

W.O.# : 90-6616
MATRIX : WATER

ND = NOT DETECTED   DF=DILUTION FACTOR

	ORGANOCHLORINE COMPOUNDS	M.D.L. ug/L	REAGENT BLANK	SW-4	SW-5	SW-6	SW-7	SW-8	SW-9
1	ALDRIN	0.0005	ND	ND	ND	ND	ND	ND	ND
2	ALPHA-BHC	0.0005	ND	ND	ND	ND	ND	ND	ND
3	BETA-BHC	0.0010	ND	ND	ND	ND	ND	ND	ND
4	DELTA-BHC	0.0005	ND	ND	ND	ND	ND	ND	ND
5	GAMMA-BHC	0.0005	ND	ND	ND	ND	0.0015	0.001	0.003
6	CHLORDANE	0.0100	ND	ND	ND	ND	ND	ND	ND
7	4,4'-DDD	0.0010	ND	ND	ND	ND	ND	ND	ND
8	4,4'-DDE	0.0005	ND	ND	ND	ND	ND	ND	ND
9	4,4'-DDT	0.0010	ND	ND	ND	ND	ND	ND	ND
10	2,4'-DDT	0.0010	ND	ND	ND	ND	ND	ND	ND
11	DIELDRIN	0.0005	ND	ND	ND	ND	ND	ND	ND
12	ENDOSULFAN I	0.0010	ND	ND	ND	ND	ND	ND	ND
13	ENDOSULFAN II	0.0005	ND	ND	ND	ND	ND	ND	ND
14	ENDOSULFAN SULPHATE	0.0010	ND	ND	ND	ND	ND	ND	ND
15	ENDRIN	0.0010	ND	ND	ND	ND	ND	ND	ND
16	ENDRIN ALDEHYDE	0.0020	ND	ND	ND	ND	ND	ND	ND
17	HEPTACHLOR	0.0005	ND	ND	ND	ND	ND	ND	0.002
18	HEPTACHLOR EPOXIDE	0.0005	ND	ND	ND	ND	ND	ND	ND
19	METHOXYCHLOR	0.0015	ND	ND	ND	ND	ND	ND	ND
20	MIREX	0.0010	ND	ND	ND	ND	ND	ND	ND
21	TOXAPHENE	0.0300	ND	ND	ND	ND	ND	ND	ND
22	TOTAL PCB'S	0.0100	ND	ND	ND	ND	ND	ND	ND

DATE : SEPT.14, 1990

W.O.# : 90-6616
MATRIX : WATER

ND = NOT DETECTED DF=DILUTION FACTOR

	ORGANOCHLORINE COMPOUNDS	M.D.L. ug/L	SW-10	SW-11	SW-12	SW-13	SW-14	SW-15	SW-16
1	ALDRIN	0.0005	ND	0.003	0.0008	ND	ND	ND	ND
2	ALPHA-BHC	0.0005	ND	0.001	ND	0.003	ND	ND	ND
3	BETA-BHC	0.0010	ND	ND	ND	ND	ND	ND	ND
4	DELTA-BHC	0.0005	ND	ND	ND	ND	ND	ND	ND
5	GAMMA-BHC	0.0005	ND	ND	ND	ND	ND	ND	ND
6	CHLORDANE	0.0100	ND	ND	ND	ND	ND	ND	ND
7	4,4'-DDD	0.0010	ND	ND	ND	ND	ND	ND	ND
8	4,4'-DDE	0.0005	ND	ND	ND	ND	ND	ND	ND
9	4,4'-DDT	0.0010	ND	ND	ND	ND	ND	ND	ND
10	2,4'-DDT	0.0010	ND	ND	ND	ND	ND	ND	ND
11	DIELDRIN	0.0005	ND	ND	ND	ND	ND	ND	ND
12	ENDOSULFAN I	0.0010	ND	ND	ND	ND	ND	ND	ND
13	ENDOSULFAN II	0.0005	ND	ND	ND	ND	ND	ND	ND
14	ENDOSULFAN SULPHATE	0.0010	ND	ND	ND	ND	ND	ND	ND
15	ENDRIN	0.0010	ND	ND	ND	ND	ND	ND	ND
16	ENDRIN ALDEHYDE	0.0020	ND	ND	ND	ND	ND	ND	ND
17	HEPTACHLOR	0.0005	ND	0.004	ND	ND	ND	ND	ND
18	HEPTACHLOR EPOXIDE	0.0005	ND	ND	ND	ND	ND	ND	ND
19	METHOXYCHLOR	0.0015	ND	ND	ND	ND	ND	ND	ND
20	MIREX	0.0010	ND	ND	ND	ND	ND	ND	ND
21	TOXAPHENE	0.0300	ND	ND	ND	ND	ND	ND	ND
22	TOTAL PCB'S	0.0100	ND	ND	ND	ND	ND	ND	ND

DATE : SEPT.14, 1990

W.O.# : 90-6616
MATRIX : WATER

ND = NOT DETECTED   DF=DILUTION FACTOR

	ORGANOCHLORINE COMPOUNDS	M.D.L. ug/L	SW-17
1	ALDRIN	0.0005	ND
2	ALPHA-BHC	0.0005	ND
3	BETA-BHC	0.0010	ND
4	DELTA-BHC	0.0005	ND
5	GAMMA-BHC	0.0005	ND
6	CHLORDANE	0.0100	ND
7	4,4'-DDD	0.0010	ND
8	4,4'-DDE	0.0005	ND
9	4,4'-DDT	0.0010	ND
10	2,4'-DDT	0.0010	ND
11	DIELDRIN	0.0005	ND
12	ENDOSULFAN I	0.0010	ND
13	ENDOSULFAN II	0.0005	ND
14	ENDOSULFAN SULPHATE	0.0010	ND
15	ENDRIN	0.0010	ND
16	ENDRIN ALDEHYDE	0.0020	ND
17	HEPTACHLOR	0.0005	ND
18	HEPTACHLOR EPOXIDE	0.0005	ND
19	METHOXYCHLOR	0.0015	ND
20	MIREX	0.0010	ND
21	TOXAPHENE	0.0300	ND
22	TOTAL PCB'S	0.0100	ND

DATE : SEPT.14, 1990

ND = NOT DETECTED   DF=DILUTION FACTOR

PERCENT RECOVERIES OF SPIKED SAMPLES

ORGANOCHLORINE COMPOUNDS

		AMOUNT SPIKED ug/L	REAGENT BLANK SPIKED
1	ALDRIN	0.003	111%
2	ALPHA-BHC	0.003	109%
3	BETA-BHC	0.003	106%
4	DELTA-BHC	0.003	120%
5	GAMMA-BHC	0.003	104%
6	CHLORDANE	--	--
7	4,4'-DDD	0.018	121%
8	4,4'-DDE	0.006	113%
9	4,4'-DDT	0.018	126%
10	2,4'-DDT	0.018	114%
11	DIELDRIN	0.006	101%
12	ENDOSULFAN I	0.006	88%
13	ENDOSULFAN II	0.006	56%
14	ENDOSULFAN SULPHATE	0.018	42%
15	ENDRIN	0.006	110%
16	ENDRIN ALDEHYDE	0.018	93%
17	HEPTACHLOR	0.003	110%
18	HEPTACHLOR EPOXIDE	0.003	112%
19	METHOXYCHLOR	0.018	130%
20	MIREX	0.018	122%
21	TOXAPHENE	--	--
22	TOTAL PCB'S	--	--

VOLATILE ORGANICS RESULTS (EPA 624)   DATE: 19-Sep-90

ND = NOT DETECTED   UNITS: MICROGRAMS/LITER (UG/L)

	COMPOUND	M.D.L. UG/L	REAGENT BLANK	SW-4	SW-5	SW-6	SW-7	SW-8	SW-9
1	CHLOROMETHANE	2.0	ND	ND	ND	ND	ND	ND	ND
2	VINYL CHLORIDE	2.0	ND	ND	ND	ND	ND	ND	ND
3	BROMOMETHANE	2.0	ND	ND	ND	ND	ND	ND	ND
4	CHLOROETHANE	5.0	ND	ND	ND	ND	ND	ND	ND
5	TRICHLOROFLUOROMETHANE	1.0	ND	ND	ND	ND	ND	ND	ND
6	1,1-DICHLOROETHENE	0.5	ND	ND	ND	ND	ND	ND	ND
7	DICHLOROMETHANE	1.0	ND	ND	ND	ND	ND	ND	ND
8	TRANS-1,2-DICHLOROETHENE	0.2	ND	ND	ND	ND	ND	ND	ND
9	1,1-DICHLOROETHANE	0.2	ND	ND	ND	ND	ND	ND	ND
10	CHLOROFORM	0.2	ND	0.2	ND	ND	ND	ND	0.4
11	1,1,1-TRICHLOROETHANE	0.2	ND	ND	ND	0.4	0.2	ND	ND
12	CARBON TETRACHLORIDE	0.2	ND	ND	ND	ND	ND	ND	ND
13	BENZENE	0.1	ND	ND	ND	ND	ND	ND	ND
14	1,2-DICHLOROETHANE	0.2	ND	ND	ND	ND	ND	ND	ND
15	TRICHLOROETHENE	0.2	ND	ND	ND	ND	ND	ND	ND
16	1,2-DICHLOROPROPANE	0.2	ND	ND	ND	ND	ND	ND	ND
17	BROMODICHLOROMETHANE	0.2	ND	ND	ND	ND	ND	ND	ND
18	CIS-1,3-DICHLOROPROPENE	0.5	ND	ND	ND	ND	ND	ND	ND
19	TOLUENE	0.2	ND	ND	ND	ND	ND	ND	ND
20	TRANS-1,3-DICHLOROPROPENE	0.5	ND	ND	ND	ND	ND	ND	ND
21	1,1,2-TRICHLOROETHANE	0.5	ND	ND	ND	ND	ND	ND	ND
22	TETRACHLOROETHENE	0.5	ND	ND	ND	ND	ND	ND	ND
23	DIBROMOCHLOROMETHANE	1.0	ND	ND	ND	ND	ND	ND	ND
24	CHLOROBENZENE	0.2	ND	ND	ND	ND	ND	ND	ND
25	ETHYLBENZENE	0.2	ND	ND	ND	ND	ND	ND	ND
26	M-XYLENE & P-XYLENE	0.2	ND	ND	ND	ND	ND	ND	ND
27	O-XYLENE	0.2	ND	ND	ND	ND	ND	ND	ND
28	BROMOFORM	2.0	ND	ND	ND	ND	ND	ND	ND
29	1,1,2,2-TETRACHLOROETHANE	1.0	ND	ND	ND	ND	ND	ND	ND
30	1,3-DICHLOROBENZENE	0.2	ND	ND	ND	ND	ND	ND	ND
31	1,4-DICHLOROBENZENE	0.2	ND	ND	ND	ND	ND	ND	ND
32	1,2-DICHLOROBENZENE	0.2	ND	ND	ND	ND	ND	ND	ND
SURROGATE STANDARD RECOVERIES:		AMOUNT							
33	FLUOROBENZENE	4 UG/L	95%	65%	61%	79%	68%	84%	80%
34	4-BROMOFLUOROBENZENE	3 UG/L	101%	107%	133%	122%	117%	120%	117%

VOLATILE ORGANICS RESULTS (EPA 624) DATE: 19-Sep-90

W.O. # 90-6616V
MATRIX:WATER

ND = NOT DETECTED

UNITS: MICROGRAMS/LITER (UG/L)

	COMPOUND	M.D.L. UG/L	SW-10	SW-11	SW-12	SW-13	SW-14	SW-15	SW-16
1	CHLOROMETHANE	2.0	ND	ND	ND	ND	ND	ND	ND
2	VINYL CHLORIDE	2.0	ND	ND	ND	ND	ND	ND	ND
3	BROMOMETHANE	2.0	ND	ND	ND	ND	ND	ND	ND
4	CHLOROETHANE	5.0	ND	ND	ND	ND	ND	ND	ND
5	TRICHLOROFLUOROMETHANE	1.0	ND	ND	ND	ND	ND	ND	ND
6	1,1-DICHLOROETHENE	0.5	ND	ND	ND	ND	ND	ND	ND
7	DICHLOROMETHANE	1.0	ND	ND	ND	ND	ND	ND	ND
8	TRANS-1,2-DICHLOROETHENE	0.2	ND	ND	ND	ND	ND	ND	ND
9	1,1-DICHLOROETHANE	0.2	ND	ND	ND	ND	ND	ND	ND
10	CHLOROFORM	0.2	ND	ND	ND	ND	ND	ND	ND
11	1,1,1-TRICHLOROETHANE	0.2	ND	ND	ND	ND	ND	0.3	ND
12	CARBON TETRACHLORIDE	0.2	ND	ND	ND	ND	ND	ND	ND
13	BENZENE	0.1	ND	ND	ND	ND	ND	ND	ND
14	1,2-DICHLOROETHANE	0.2	ND	ND	ND	ND	ND	ND	ND
15	TRICHLOROETHENE	0.2	ND	ND	ND	ND	ND	ND	ND
16	1,2-DICHLOROPROPANE	0.2	ND	ND	ND	ND	ND	ND	ND
17	BROMODICHLOROMETHANE	0.2	ND	ND	ND	ND	ND	ND	ND
18	CIS-1,3-DICHLOROPROPENE	0.5	ND	ND	ND	ND	ND	ND	ND
19	TOLUENE	0.2	ND	ND	ND	ND	ND	ND	ND
20	TRANS-1,3-DICHLOROPROPENE	0.5	ND	ND	ND	ND	ND	ND	ND
21	1,1,2-TRICHLOROETHANE	0.5	ND	ND	ND	ND	ND	ND	ND
22	TETRACHLOROETHENE	0.5	ND	ND	ND	ND	ND	ND	ND
23	DIBROMOCHLOROMETHANE	1.0	ND	ND	ND	ND	ND	ND	ND
24	CHLOROBENZENE	0.2	ND	ND	ND	ND	ND	ND	ND
25	ETHYLBENZENE	0.2	ND	ND	ND	ND	ND	ND	ND
26	M-XYLENE & P-XYLENE	0.2	ND	ND	ND	ND	ND	ND	ND
27	O-XYLENE	0.2	ND	ND	ND	ND	ND	ND	ND
28	BROMOFORM	2.0	ND	ND	ND	ND	ND	ND	ND
29	1,1,2,2-TETRACHLOROETHANE	1.0	ND	ND	ND	ND	ND	ND	ND
30	1,3-DICHLOROBENZENE	0.2	ND	ND	ND	ND	ND	ND	ND
31	1,4-DICHLOROBENZENE	0.2	ND	ND	ND	ND	ND	ND	ND
32	1,2-DICHLOROBENZENE	0.2	ND	ND	ND	ND	ND	ND	ND
SURROGATE STANDARD RECOVERIES:		AMOUNT							
33	FLUOROBENZENE	4 UG/L	93%	86%	83%	78%	76%	69%	67%
34	4-BROMOFLUOROBENZENE	3 UG/L	95%	107%	105%	110%	125%	130%	124%

VOLATILE ORGANICS RESULTS (EPA 624) DATE: 19-Sep-90

PROJECT REF #90-11Y
W.O. # 90-6616V
MATRIX:WATER

ND = NOT DETECTED

UNITS: MICROGRAMS/LITER (UG/L)

	COMPOUND	M.D.L. UG/L	SW-17	SW-17 REPEAT
1	CHLOROMETHANE	2.0	ND	ND
2	VINYL CHLORIDE	2.0	ND	ND
3	BROMOMETHANE	2.0	ND	ND
4	CHLOROETHANE	5.0	ND	ND
5	TRICHLOROFLUOROMETHANE	1.0	ND	ND
6	1,1-DICHLOROETHENE	0.5	ND	ND
7	DICHLOROMETHANE	1.0	ND	ND
8	TRANS-1,2-DICHLOROETHENE	0.2	ND	ND
9	1,1-DICHLOROETHANE	0.2	ND	ND
10	CHLOROFORM	0.2	ND	ND
11	1,1,1-TRICHLOROETHANE	0.2	ND	ND
12	CARBON TETRACHLORIDE	0.2	ND	ND
13	BENZENE	0.1	ND	ND
14	1,2-DICHLOROETHANE	0.2	ND	ND
15	TRICHLOROETHENE	0.2	ND	ND
16	1,2-DICHLOROPROPANE	0.2	ND	ND
17	BROMODICHLOROMETHANE	0.2	ND	ND
18	CIS-1,3-DICHLOROPROPENE	0.5	ND	ND
19	TOLUENE	0.2	ND	ND
20	TRANS-1,3-DICHLOROPROPENE	0.5	ND	ND
21	1,1,2-TRICHLOROETHANE	0.5	ND	ND
22	TETRACHLOROETHENE	0.5	ND	ND
23	DIBROMOCHLOROMETHANE	1.0	ND	ND
24	CHLOROBENZENE	0.2	ND	ND
25	ETHYLBENZENE	0.2	ND	ND
26	M-XYLENE & P-XYLENE	0.2	ND	ND
27	O-XYLENE	0.2	ND	ND
28	BROMOFORM	2.0	ND	ND
29	1,1,2,2-TETRACHLOROETHANE	1.0	ND	ND
30	1,3-DICHLOROBENZENE	0.2	ND	ND
31	1,4-DICHLOROBENZENE	0.2	ND	ND
32	1,2-DICHLOROBENZENE	0.2	ND	ND
	SURROGATE STANDARD RECOVERIES:	AMOUNT		
33	FLUOROBENZENE	4 UG/L	58%	60%
34	4-BROMOFLUOROBENZENE	3 UG/L	125%	128%

QUALITY CONTROL SPIKE PERCENT RECOVERIES DATE: 19-Sep-90

W.O. # 90-6616V
MATRIX:WATER

	COMPOUND	AMOUNT UG/L	SW-10 SPIKE
1	CHLOROMETHANE	10.0	83%
2	VINYL CHLORIDE	10.0	116%
3	BROMOMETHANE	10.0	108%
4	CHLOROETHANE	10.0	171%
5	TRICHLOROFLUOROMETHANE	5.0	108%
6	1,1-DICHLOROETHENE	5.0	114%
7	DICHLOROMETHANE	5.0	63%
8	TRANS-1,2-DICHLOROETHENE	5.0	105%
9	1,1-DICHLOROETHANE	5.0	103%
10	CHLOROFORM	5.0	107%
11	1,1,1-TRICHLOROETHANE	5.0	101%
12	CARBON TETRACHLORIDE	5.0	97%
13	BENZENE	5.0	108%
14	1,2-DICHLOROETHANE	5.0	103%
15	TRICHLOROETHENE	5.0	116%
16	1,2-DICHLOROPROPANE	5.0	114%
17	BROMODICHLOROMETHANE	5.0	101%
18	CIS-1,3-DICHLOROPROPENE	7.5	109%
19	TOLUENE	5.0	106%
20	TRANS-1,3-DICHLOROPROPENE	2.5	102%
21	1,1,2-TRICHLOROETHANE	5.0	100%
22	TETRACHLOROETHENE	5.0	101%
23	DIBROMOCHLOROMETHANE	5.0	105%
24	CHLOROBENZENE	5.0	102%
25	ETHYLBENZENE	5.0	109%
26	M-XYLENE & P-XYLENE	1.6	107%
27	O-XYLENE	1.6	121%
28	BROMOFORM	5.0	102%
29	1,1,2,2-TETRACHLOROETHANE	5.0	115%
30	1,3-DICHLOROBENZENE	3.1	112%
31	1,4-DICHLOROBENZENE	2.7	100%
32	1,2-DICHLOROBENZENE	3.2	120%

SURROGATE STANDARD RECOVERIES:

33	FLUOROBENZENE	3.6	102%
34	4-BROMOFLUOROBENZENE	3.0	107%

25-May-90

Page: 1
Copy: 1 of 2
Set : 1

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905228 Status: Final

Type	Sample	F- IC mg/L	Cl- IC mg/L	NO2-N IC mg/L	PO4-3 IC mg/L	Br- IC mg/L	NO3-N IC mg/L	SO4= IC mg/L
water	SWZ-1	<0.1	289.	<0.20	<1.0	0.41	0.16	18.1
	SWZ-2	<0.1	103.	<0.20	<1.0	0.35	<0.02	2.22
	SWZ-3	<0.1	325.	<0.20	<1.0	0.37	<0.02	23.7
	SWZ-4	<0.1	296.	<0.20	<1.0	0.24	0.49	443.
	SWZ-5	<0.1	7.31	<0.02	<0.1	<0.05	0.06	9.62
	SWZ-6	<0.1	5.86	<0.02	<0.1	<0.05	0.06	9.10
	SWZ-7	<0.1	5.69	<0.02	<0.1	<0.05	0.05	8.93
	SWZ-8	<0.1	9.61	<0.02	<0.1	<0.05	0.09	12.1
	SWZ-9	<0.1	14.0	<0.20	<0.1	<0.50	0.12	13.1
	SWZ-10	<0.1	309.	<0.20	<1.0	0.28	0.44	44.2
	Blank	<0.1	<0.01	<0.20	<1.0	<0.05	0.16	<0.05
	QC Standard (actual)	0.4	25.5	1.08	2.0	1.89	0.43	61.7
	QC Standard (expected)	0.4	25.0	1.00	<2.0	2.00	0.44	60.0
	Repeat SWZ-1	<0.1	279.	<0.20	1.0	0.40	0.16	18.4

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905228 Status: Final

Type	Sample	TKN A. Col. mg/L	BOD DO Elec. mg/L	Phenols 4-AAP mg/L	TSS Grav. mg/L	Total P A. Col. mg/L	Ag ICAP mg/L	Al ICAP mg/L
water	SWZ-1	21.4	11.2	<0.0005	326.5	0.067	<0.0003	<0.003
	SWZ-2	1.71	5.8	0.0080	25.6	0.200	<0.0003	<0.003
	SWZ-3	17.7	9.0	<0.0005	67.9	0.017	<0.0003	<0.003
	SWZ-4	5.10	2.8	<0.0005	16.4	0.022	<0.0003	<0.003
	SWZ-5	0.61	4.2	<0.0005	4.8	0.025	<0.0003	<0.003
	SWZ-6	0.53	4.0	<0.0005	8.4	0.022	<0.0003	<0.003
	SWZ-7	0.55	4.4	<0.0005	16.9	0.019	<0.0003	<0.003
	SWZ-8	0.58	4.3	<0.0005	44.5	0.019	<0.0003	<0.003
	SWZ-9	0.88	4.6	<0.0005	22.8	0.026	<0.0003	0.501
	SWZ-10	5.90	4.6	<0.0005	20.8	0.020	<0.0003	<0.003
	Blank	<0.02	<0.5	<0.0005	<0.1	<0.002	<0.0003	<0.003
	QC Standard (actual)	1.39	4.1	0.0100	47.4	0.084	<0.0005	0.161
	QC Standard (expected)	1.40	4.1	0.0100	50.0	0.084	<0.0005	0.200
	Repeat SWZ-1	22.5	10.5	<0.0005	336.0	0.082	<0.0003	<0.003

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905228 Status: Final

Type	Sample	Cu ICAP mg/L	Fe ICAP mg/L	K ICAP mg/L	Mg ICAP mg/L	Mn ICAP mg/L	Mo ICAP mg/L	Na ICAP mg/L
water	SWZ-1	0.003	15.9	22.9	21.7	0.751	<0.01	184.
	SWZ-2	0.002	1.01	28.5	22.5	2.69	<0.01	72.8
	SWZ-3	0.001	11.2	15.6	16.6	0.642	0.01	207.
	SWZ-4	0.005	0.605	20.3	15.8	0.150	<0.01	183.
	SWZ-5	0.001	0.163	1.57	4.57	0.056	<0.01	4.65
	SWZ-6	0.002	0.193	1.47	4.44	0.060	<0.01	3.62
	SWZ-7	0.001	0.203	1.47	4.43	0.087	<0.01	3.60
	SWZ-8	0.001	0.288	1.79	4.21	0.067	<0.01	5.61
	SWZ-9	0.001	0.520	1.97	4.63	0.048	<0.01	8.18
	SWZ-10	0.006	0.501	20.5	15.3	0.107	<0.01	172.
	Blank	<0.001	0.002	<0.03	0.008	<0.001	<0.01	0.04
	QC Standard (actual)	0.197	0.188	1.12	0.224	0.193	0.20	1.98
	QC Standard (expected)	0.200	0.200	1.00	0.200	0.200	0.20	2.00
	Repeat SWZ-1	0.003	15.9	22.9	21.7	0.751	<0.01	184.

L3R 8B6

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905228 Status: Final

Type	Sample	Ni ICAP mg/L	P ICAP mg/L	Pb ICAP mg/L	Si ICAP mg/L	Sr ICAP mg/L	Th ICAP mg/L	Ti ICAP mg/L
water	SWZ-1	0.004	0.28	0.012	2.16	0.783	<0.003	0.0068
	SWZ-2	0.004	0.29	<0.003	2.03	0.649	<0.003	0.0009
	SWZ-3	0.005	0.18	<0.003	2.36	0.714	<0.003	0.0008
	SWZ-4	0.006	0.16	0.004	1.99	0.719	<0.003	0.0011
	SWZ-5	0.006	0.09	0.004	0.738	0.293	<0.003	0.0009
	SWZ-6	0.005	0.09	0.004	0.407	0.293	<0.003	0.0011
	SWZ-7	0.006	0.09	0.004	0.726	0.291	<0.003	0.0013
	SWZ-8	0.005	0.11	0.004	0.200	0.120	0.003	0.0032
	SWZ-9	0.004	0.11	0.003	0.215	0.138	0.003	0.0020
	SWZ-10	0.007	0.16	0.010	0.807	0.714	<0.003	0.0010
	Blank	<0.003	<0.03	<0.003	0.003	<0.0003	<0.003	<0.0003
	QC Standard (actual)	0.200	0.30	0.200	0.121	0.211	0.330	0.0452
	QC Standard (expected)	0.200	N	0.200	<0.050	0.200	0.200	0.200
	Repeat SWZ-1	0.004	0.28	0.012	3.22	0.783	<0.003	0.0060

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905228 Status: Final

Type	Sample	V ICAP mg/L	Zn ICAP mg/L	Zr ICAP mg/L
water	SWZ-1	<0.0003	0.003	0.007
	SWZ-2	<0.0003	<0.001	0.015
	SWZ-3	<0.0003	0.001	0.006
	SWZ-4	<0.0003	0.104	0.003
	SWZ-5	0.0006	0.004	0.001
	SWZ-6	0.0004	0.005	0.001
	SWZ-7	0.0004	0.004	0.001
	SWZ-8	0.0006	0.004	0.001
	SWZ-9	0.0003	0.004	0.001
	SWZ-10	<0.0003	0.115	0.002
	Blank	<0.0003	0.001	<0.001
	QC Standard (actual)	0.198	0.201	0.033
	QC Standard (expected)	0.200	0.200	0.200
	Repeat SWZ-1	<0.0003	0.003	0.011

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905228 Status: Final

Abbreviations:

Analyses:

F-	:	Fluoride ion concentration
Cl-	:	Chloride ion concentration
NO2-N	:	Nitrite ion concentration expressed as nitrogen
PO4-3	:	Phosphate ion concentration
Br-	:	Bromide ion concentration
NO3-N	:	Nitrate ion concentration expressed as nitrogen
SO4=	:	Total Sulphate ion concentration
TKN	:	Total Kjeldahl Nitrogen (Tot. N minus NO2-N & NO3-N)
BOD	:	Biochemical Oxygen Demand
Phenols	:	Phenolic compounds determined using the 4-AAP method
TSS	:	Total Suspended Solids
Total P	:	Total Phosphorus concentration
Ag	:	Silver concentration
Al	:	Aluminum concentration
B	:	Boron concentration
Ba	:	Barium concentration
Be	:	Beryllium concentration
Ca	:	Calcium concentration
Cd	:	Cadmium concentration
Co	:	Cobalt concentration
Cr	:	Chromium concentration

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905228 Status: Final

Cu	:	Copper concentration
Fe	:	Total Iron Concentration
K	:	Potassium concentration
Mg	:	Magnesium concentration
Mn	:	Manganese concentration
Mo	:	Molybdenum concentration
Na	:	Sodium concentration
Ni	:	Nickel concentration
P	:	Phosphorus concentration
Pb	:	Lead concentration
Si	:	Silicon concentration
Sr	:	Strontium concentration
Th	:	Thorium concentration
Ti	:	Titanium concentration
V	:	Vanadium concentration
Zn	:	Zinc concentration
Zr	:	Zirconium concentration

Methods:

IC	:	Ion Chromatography
A. Col.	:	Automated Colourimetry
DO Elec.	:	Dissolved Oxygen Electrode
4-AAP	:	Colourimetry using 4-AAP method
Grav.	:	Gravimetric determination by weight
ICAP	:	Inductively-Coupled Argon Plasma Spectroscopy

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905228 Status: Final

Units:

mg/L : Milligrams per Liter

Quality control:

< : Result obtained was below the detection limit
N : Not Applicable

Signed:
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Agnes Love, B.Sc.
Supervisor, Environmental Inorganic Services

CLIENT:GARTNER LEE LTD. VOLATILE ORGANICS RESULTS (EPA 624) DATE: 24-May-90
PROJECT REF #90-119
W.O. # 90-5228V ND = NOT DETECTED
MATRIX:WATER DF = DILUTION FACTOR

	COMPOUND	M.D.L. UG/L	REAGENT BLANK	TRAVEL BLANK	SWZ-1	SWZ-2 DF=5	SWZ-3	SWZ-4	SWZ-5
1	CHLOROMETHANE	2.0	ND	ND	ND	ND	ND	ND	ND
2	VINYL CHLORIDE	2.0	ND	ND	ND	ND	ND	ND	ND
3	BROMOMETHANE	2.0	ND	ND	ND	ND	ND	ND	ND
4	CHLOROETHANE	5.0	ND	ND	ND	ND	ND	ND	ND
5	TRICHLOROFLUOROMETHANE	1.0	ND	ND	ND	ND	ND	ND	ND
6	1,1-DICHLOROETHENE	0.5	ND	ND	ND	ND	ND	ND	ND
7	DICHLOROMETHANE	2.0	ND	ND	ND	ND	ND	ND	ND
8	TRANS-1,2-DICHLOROETHENE	0.2	ND	ND	ND	ND	ND	ND	ND
9	1,1-DICHLOROETHANE	0.2	ND	ND	ND	ND	ND	ND	ND
10	CHLOROFORM	0.2	ND	0.2	ND	ND	ND	12.7	ND
11	1,1,1-TRICHLOROETHANE	0.2	ND	ND	ND	ND	ND	ND	ND
12	CARBON TETRACHLORIDE	0.2	ND	ND	ND	ND	ND	ND	ND
13	BENZENE	0.1	ND	ND	0.2	ND	1.7	ND	ND
14	1,2-DICHLOROETHANE	0.2	ND	ND	ND	ND	ND	ND	ND
15	TRICHLOROETHENE	0.2	ND	ND	ND	ND	ND	ND	ND
16	1,2-DICHLOROPROPANE	0.2	ND	ND	ND	ND	ND	ND	ND
17	BROMODICHLOROMETHANE	0.2	ND	0.5	ND	ND	ND	0.2	ND
18	CIS-1,3-DICHLOROPROPENE	0.5	ND	ND	ND	ND	ND	ND	ND
19	TOLUENE	0.2	ND	ND	ND	ND	ND	ND	ND
20	TRANS-1,3-DICHLOROPROPENE	0.5	ND	ND	ND	ND	ND	ND	ND
21	1,1,2-TRICHLOROETHANE	0.5	ND	ND	ND	ND	ND	ND	ND
22	TETRACHLOROETHENE	0.5	ND	ND	ND	ND	ND	ND	ND
23	DIBROMOCHLOROMETHANE	1.0	ND	ND	ND	ND	ND	ND	ND
24	CHLOROBENZENE	0.2	ND	ND	1.0	ND	1.5	ND	ND
25	ETHYLBENZENE	0.2	ND	ND	ND	ND	ND	ND	ND
26	M-XYLENE & P-XYLENE	0.2	ND	ND	ND	ND	ND	ND	ND
27	O-XYLENE	0.2	ND	ND	ND	ND	ND	ND	ND
28	BROMOFORM	2.0	ND	ND	ND	ND	ND	ND	ND
29	1,1,2,2-TETRACHLOROETHANE	1.0	ND	ND	ND	ND	ND	ND	ND
30	1,3-DICHLOROBENZENE	0.2	ND	ND	ND	ND	ND	ND	ND
31	1,4-DICHLOROBENZENE	0.2	ND	ND	ND	ND	1.2	0.3	ND
32	1,2-DICHLOROBENZENE	0.2	ND	ND	ND	ND	ND	ND	ND
	SURROGATE STANDARD RECOVERIES:	AMOUNT							
33	FLUOROBENZENE	4 UG/L	90%	101%	129%	50%	98%	105%	94%
34	4-BROMOFLUOROBENZENE	3 UG/L	130%	100%	79%	136%	135%	118%	116%

CLIENT
PROJECT REF #90-119
W.O. # 90-5228V
MATRIX:WATER

VOLATILE ORGANICS RESULTS (EPA 624)

DATE: 24-May-90

ND = NOT DETECTED
DF = DILUTION FACTOR

	COMPOUND	M.D.L. UG/L	SWZ-6	SWZ-6 REPEAT	SWZ-7	SWZ-8	SWZ-9	SWZ-10
1	CHLOROMETHANE	2.0	ND	ND	ND	ND	ND	ND
2	VINYL CHLORIDE	2.0	ND	ND	ND	ND	ND	ND
3	BROMOMETHANE	2.0	ND	ND	ND	ND	ND	ND
4	CHLOROETHANE	5.0	ND	ND	ND	ND	ND	ND
5	TRICHLOROFLUOROMETHANE	1.0	ND	ND	ND	ND	ND	ND
6	1,1-DICHLOROETHENE	0.5	ND	ND	ND	ND	ND	ND
7	DICHLOROMETHANE	1.0	ND	ND	ND	ND	ND	ND
8	TRANS-1,2-DICHLOROETHENE	0.2	ND	ND	ND	ND	ND	ND
9	1,1-DICHLOROETHANE	0.2	ND	ND	ND	ND	ND	ND
10	CHLOROFORM	0.2	ND	ND	ND	ND	5.5	6.6
11	1,1,1-TRICHLOROETHANE	0.2	ND	ND	ND	ND	ND	ND
12	CARBON TETRACHLORIDE	0.2	ND	ND	ND	ND	ND	ND
13	BENZENE	0.1	ND	ND	ND	ND	ND	ND
14	1,2-DICHLOROETHANE	0.2	ND	ND	ND	ND	ND	ND
15	TRICHLOROETHENE	0.2	ND	ND	ND	ND	ND	ND
16	1,2-DICHLOROPROPANE	0.2	ND	ND	ND	ND	ND	ND
17	BROMODICHLOROMETHANE	0.2	ND	ND	ND	ND	ND	0.2
18	CIS-1,3-DICHLOROPROPENE	0.5	ND	ND	ND	ND	ND	ND
19	TOLUENE	0.2	ND	ND	ND	ND	ND	ND
20	TRANS-1,3-DICHLOROPROPENE	0.5	ND	ND	ND	ND	ND	ND
21	1,1,2-TRICHLOROETHANE	0.5	ND	ND	ND	ND	ND	ND
22	TETRACHLOROETHENE	0.5	ND	ND	ND	ND	ND	ND
23	DIBROMOCHLOROMETHANE	1.0	ND	ND	ND	ND	ND	ND
24	CHLOROBENZENE	0.2	ND	ND	ND	ND	ND	ND
25	ETHYLBENZENE	0.2	ND	ND	ND	ND	ND	ND
26	M-XYLENE & P-XYLENE	0.2	ND	ND	ND	ND	ND	ND
27	O-XYLENE	0.2	ND	ND	ND	ND	ND	ND
28	BROMOFORM	2.0	ND	ND	ND	ND	ND	ND
29	1,1,2,2-TETRACHLOROETHANE	1.0	ND	ND	ND	ND	ND	ND
30	1,3-DICHLOROBENZENE	0.2	ND	ND	ND	ND	ND	ND
31	1,4-DICHLOROBENZENE	0.2	ND	ND	ND	ND	ND	0.4
32	1,2-DICHLOROBENZENE	0.2	ND	ND	ND	ND	ND	ND

	SURROGATE STANDARD RECOVERIES:	AMOUNT						
33	FLUOROBENZENE	4 UG/L	197%	114%	149%	127%	78%	83%
34	4-BROMOFLUOROBENZENE	3 UG/L	102%	125%	115%	119%	107%	126%

CLIENT: QUALITY CONTROL SPIKE PERCENT RECOVERIES DATE: 24-May-90
PROJECT REF #90-119
W.O. # 90-5228V
MATRIX:WATER

	COMPOUND	AMOUNT UG/L	REAGENT SPIKE
1	CHLOROMETHANE	10.0	124%
2	VINYL CHLORIDE	10.0	128%
3	BROMOMETHANE	10.0	124%
4	CHLOROETHANE	10.0	131%
5	TRICHLOROFLUOROMETHANE	5.0	119%
6	1,1-DICHLOROETHENE	5.0	130%
7	DICHLOROMETHANE	5.0	92%
8	TRANS-1,2-DICHLOROETHENE	5.0	128%
9	1,1-DICHLOROETHANE	5.0	114%
10	CHLOROFORM	5.0	178%
11	1,1,1-TRICHLOROETHANE	5.0	117%
12	CARBON TETRACHLORIDE	5.0	125%
13	BENZENE	5.0	153%
14	1,2-DICHLOROETHANE	5.0	87%
15	TRICHLOROETHENE	5.0	188%
16	1,2-DICHLOROPROPANE	5.0	65%
17	BROMODICHLOROMETHANE	5.0	117%
18	CIS-1,3-DICHLOROPROPENE	7.5	102%
19	TOLUENE	5.0	103%
20	TRANS-1,3-DICHLOROPROPENE	2.5	99%
21	1,1,2-TRICHLOROETHANE	5.0	102%
22	TETRACHLOROETHENE	5.0	107%
23	DIBROMOCHLOROMETHANE	5.0	98%
24	CHLOROBENZENE	5.0	101%
25	ETHYLBENZENE	5.0	104%
26	M-XYLENE & P-XYLENE	1.6	102%
27	O-XYLENE	1.6	101%
28	BROMOFORM	5.0	102%
29	1,1,2,2-TETRACHLOROETHANE	5.0	99%
30	1,3-DICHLOROBENZENE	3.1	104%
31	1,4-DICHLOROBENZENE	2.7	101%
32	1,2-DICHLOROBENZENE	3.2	104%

SURROGATE STANDARD RECOVERIES:

33	FLUOROBENZENE	3.6	102%
34	4-BROMOFLUOROBENZENE	3.0	102%

RESULTS FROM JUNE SAMPLING EVENT

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905658 Status: Final

Type	Sample	pH pH Elec. pH Units	Tot. Alk. Titr. 1 mg CaCO3/L	Sp. Cond. SS Elec. umhos/cm	F- IC mg/L	Cl- IC mg/L	NO2-N IC mg/L	PO4-3 IC mg/L
water	SW-3	7.58	604	1990	0.17	329.	0.01	<1.0
	SW-4	7.52	442	1600	0.15	251.	0.16	<1.0
	SW-5	7.23	179	434	0.13	32.1	0.01	<1.0
	SW-6	7.53	114	252	0.11	7.46	0.00	<1.0
	SW-7	7.33	116	249	0.11	8.59	0.00	<1.0
	SW-8	7.48	111	251	0.11	8.08	0.00	<1.0
	SW-9	7.24	106	253	0.13	12.2	0.00	<1.0
	SW-10	7.48	436	1600	0.23	258.	0.15	<1.0
	Blank	5.44	1	2	<0.10	<0.01	<0.00	<0.1
	QC Standard (actual)	4.45	247	716	0.58	24.6	0.01	2.0
	QC Standard (expected)	4.45	250	718	0.60	25.0	0.01	2.0
	Repeat SW-3	7.48	580	1990	0.18	328.	0.01	<1.0

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905658 Status: Final

Type	Sample	Br- IC mg/L	NO3-N IC mg/L	SO4= IC mg/L	TKN A. Col. mg/L	NH3-N A. Col. mg/L	Total P A. Col. mg/L	BOD DO Elec. mg/L
water	SW-3	<0.50	<0.02	<0.50	18.0	9.80	0.036	2.6
	SW-4	<0.50	0.32	30.3	3.80	2.30	0.023	4.0
	SW-5	<0.50	0.23	15.3	0.89	0.34	0.023	5.0
	SW-6	<0.50	0.02	9.07	0.53	0.03	0.039	4.0
	SW-7	<0.50	0.06	9.45	0.45	0.02	0.034	3.8
	SW-8	<0.50	0.03	9.31	0.44	0.05	0.008	4.0
	SW-9	<0.50	<0.02	11.0	0.54	0.12	0.012	4.5
	SW-10	<0.50	0.28	30.6	3.50	3.40	0.010	4.0
	Blank	<0.05	<0.02	<0.05	<0.02	<0.02	<0.002	0.3
	QC Standard (actual)	1.82	0.45	60.4	0.85	0.48	0.081	4.1
	QC Standard (expected)	2.00	0.44	60.0	0.84	0.50	0.081	4.0
	Repeat SW-3	<0.50	<0.02	<0.05	18.0	9.80	0.023	3.5

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905658 Status: Final

Type	Sample	DOC A. Col. mg/L	TOC A. Col. mg/L	TDS Grav. mg/L	TSS Grav. mg/L	Phenols 4-AAP mg/L	C-Hard. Calc. mg CaCO3/L	Ag ICAP mg/L
water	SW-3	14.8	15.0	1067	105.80	0.0025	552.8	<0.0003
	SW-4	9.5	9.7	910	802.90	<0.0005	450.4	<0.0003
	SW-5	7.9	8.3	258	21.30	<0.0005	190.5	<0.0003
	SW-6	7.2	7.9	272	2.00	<0.0005	121.8	<0.0003
	SW-7	6.8	7.5	161	28.55	<0.0005	125.2	<0.0003
	SW-8	6.7	7.6	162	7.45	<0.0005	120.8	<0.0003
	SW-9	5.5	6.4	155	6.85	<0.0005	119.5	<0.0003
	SW-10	9.5	8.7	911	359.05	<0.0005	452.9	<0.0003
	Blank	<0.2	<0.2	<1	<0.05	<0.0005	<0.1	<0.0003
	QC Standard (actual)	10.1	10.1	264	46.90	0.0100	28.3	<0.0003
	QC Standard (expected)	10.0	10.0	250	50.00	0.0100	27.1	<0.0003
	Repeat SW-3	13.8	15.0	1064	109.05	0.0030	556.4	<0.0003

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905658 Status: Final

Type	Sample	Al ICAP mg/L	B ICAP mg/L	Ba ICAP mg/L	Be ICAP mg/L	Ca ICAP mg/L	Cd ICAP mg/L	Co ICAP mg/L
water	SW-3	0.031	0.138	0.344	<0.00003	199.	<0.0003	<0.003
	SW-4	0.257	0.193	0.322	<0.00003	480.	<0.0003	<0.003
	SW-5	0.263	0.0336	0.0785	<0.00003	67.0	<0.0003	<0.003
	SW-6	0.050	0.0106	0.0511	<0.00003	42.2	<0.0003	<0.003
	SW-7	0.225	0.0116	0.0549	<0.00003	43.6	<0.0003	<0.003
	SW-8	0.120	0.0116	0.0467	<0.00003	42.0	<0.0003	<0.003
	SW-9	0.291	0.0116	0.0294	<0.00003	42.5	<0.0003	<0.003
	SW-10	0.151	0.191	0.286	<0.00003	452.	<0.0003	<0.003
	Blank	<0.003	<0.0050	<0.0003	<0.00003	<0.05	<0.0003	<0.003
	QC Standard (actual)	0.993	0.191	0.0370	0.0176	10.6	0.167	0.170
	QC Standard (expected)	1.00	0.200	0.0400	0.0200	10.0	0.200	0.200
	Repeat SW-3	0.030	0.137	0.340	<0.00003	201.	<0.0003	<0.003

Authority: Ms. Cynthia Russel
Project : 90-119 Purchase order :

Job: 905658 Status: Final

Type	Sample	Cr ICAP mg/L	Cu ICAP mg/L	Fe ICAP mg/L	K ICAP mg/L	Mg ICAP mg/L	Mn ICAP mg/L	Mo ICAP mg/L
water	SW-3	0.0006	0.0082	17.6	13.4	13.2	0.429	<0.01
	SW-4	0.0014	0.0088	10.7	16.1	16.5	0.668	<0.01
	SW-5	0.0019	0.0056	1.90	3.02	5.52	0.112	<0.01
	SW-6	0.0014	0.0007	0.201	0.99	3.92	0.0649	<0.01
	SW-7	0.0019	0.0011	0.556	1.02	3.89	0.198	<0.01
	SW-8	0.0021	0.0011	0.208	1.02	3.82	0.0515	<0.01
	SW-9	0.0014	0.0122	0.148	1.16	3.21	0.0289	<0.01
	SW-10	0.0011	0.0061	6.25	15.7	16.5	0.581	<0.01
	Blank	0.0005	<0.0005	0.0023	<0.03	0.0029	<0.0005	<0.01
	QC Standard (actual)	0.191	0.173	0.909	0.05	0.433	0.168	0.17
	QC Standard (expected)	0.200	0.200	1.00	1.00	0.500	0.200	0.20
	Repeat SW-3	0.0005	0.0081	17.0	13.3	12.8	0.425	<0.01

APPENDIX F

RECOMMENDED WATER QUALITY MONITORING PROGRAM

RECOMMENDED WATER QUALITY MONITORING PROGRAM

A surface and ground water monitoring program is recommended to supplement the existing database for water quality on Zwick's Island and the adjacent Bay of Quinte. The monitoring program is seen to serve the following purposes:

- to help confirm the results and conclusions of the present study;
- to monitor for any significant water quality variation not identified by the present study; and,
- to provide a substantial database to assist in determining the need for and planning any remedial actions.

While a monitoring program has been recommended herein, any monitoring actually undertaken should be routinely reviewed and revised as necessary. It is also important to identify any other water quality monitoring efforts being undertaken in the immediate vicinity so that monitoring efforts may be coordinated and unnecessary duplication avoided.

MONITORING STATIONS

Monitoring stations have been chosen to allow analysis of water quality as flow progresses from the contaminate source (the wastes) to the ultimate receptor (the Bay of Quinte). The following stations are recommended:

Ground Water Monitors	Surface Water Stations
BH4	SW8
BH7	SW1, SW4, SW5
BH8	SW9
	SW17

MONITORING FREQUENCY

Monitoring is recommended to be carried out four times per year to identify temporal changes in water quality.

FIELD MEASUREMENTS AND ANALYTICAL PARAMETERS

Measurements and analytical parameters have been chosen so as to provide a good indication of overall water quality as well as the perceived need to assess the effect of water quality on human health. It is noted that the parameters chosen for laboratory analysis do not constitute a full list, and should be supplemented as required. The following is recommended:

Surface Water Field Measurements

- pH
- temperature
- dissolved oxygen
- conductivity
- flow
- Bay of Quinte water level

Ground Water Field Measurements

- measurement of static water levels

Laboratory Analyses For Surface Water Stations Only

- fecal colliform bacteria
- total colliform bacteria
- fecal streptococci bacteria
- turbidity
- temperature

Laboratory Analyses For Surface and Ground Water Stations

- unionized ammonia
- chloride
- hydrogen sulphide
- dissolved oxygen
- phenols
- total phosphorus
- arsenic
- cadmium
- chromium
- copper
- iron
- lead
- mercury
- nickel
- selenium
- silver
- zinc
- chloride
- TKN
- DOC
- conductivity
- total nitrogen
- alkalinity
- pH

Analysis for volatile organics and pesticides are not viewed as essential since very low to non–detectable levels were found during the present study.

QUALITY ASSURANCE / QUALITY CONTROL

The monitoring program should incorporate QA/QC procedures. The following are recommended:

- blind duplicate samples;
- laboratory and field blank samples;
- laboratory QC through spiked samples; and
- auditing of laboratory sample quality through calculation of ionic balances.